Model 7013
Calibration Bath
User Manual

HART SCIENTIFIC

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WARNING

To ensure the safety of operating personnel, and to avoid damage to this unit:

DO NOT operate this unit without a properly grounded, properly polarized power cord.
DO NOT connect this unit to a non-grounded, non-polarized outlet.

DO use a ground fault interrupt device.

WARNING

EXTREMELY COLD TEMPERATURES PRESENT
in this equipment.
FREEZER BURNS AND FROSTBITE
may result if personnel fail to observe safety precautions.

WARNING

HIGH TEMPERATURES PRESENT
in this equipment.
FIRES AND SEVERE BURNS
may result if personnel fail to observe safety precautions.

WARNING

Fluids used in this bath may produce
NOXIOUS OR TOXIC FUMES
under certain circumstances.
Consult the fluid manufacturer's MSDS (Material Safety Data Sheet).
PROPER VENTILATION AND
SAFETY PRECAUTIONS MUST BE OBSERVED.

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1 Introduction

The Hart Scientific Model 7013 is a precision dual temperature calibration bath. The cold bath has a normal operating range of –100°C to 70°C and the hot bath has a range of 60°C to 300°C for a 400°C overall range. It is capable of rapid heating and cooling rates and is highly stable and accurate at all temperature settings.

The Model 7013 consists of two independently operable bath systems. Each bath has its own tank with a constant level test well and pump. Each has its own temperature controller, probe, and heating and cooling systems. Separate front panel power controls, labeled Hot Bath and Cold Bath, allow independent power up and use.

The temperature controller can be directly set to 0.01°C with the button-switches and digital display on the front panel. A digital vernier may be used to adjust to intermediate temperatures.

The probe clamp and stand permits support of a temperature measurement standard probe or support of probes being calibrated.

2 Specifications

Power Requirements	208 to 230 VAC, single phase, 60 Hz		
	NOTE: See the installation instructions before powering unit. Compressors require 230 VAC nominal.		
	Hot Bath	10 amps max 3 amps normal controlling	
	Cold Bath	30 amps starting 9 - 14 amps normal operating	
Temperature Range	Hot Bath	60°C to 300°C	
	Cold Bath	–100°C to 70°C	
	NOTE: Range applies only when using specified fluids.		
Temperature Change Rates	Hot Bath (heating)	25°C to 300°C in 45 minutes max (Q 230 VAC)	
	Cold Bath (cooling)	25°C to -100°C in 180 minutes max	
Temperature Stability and Time Required to Reach Stability	**Temperature Range**	**Time to Reach Stability**	**Stability**
	–100°C to –40°C	60 minutes max	±0.05°C
	140°C to 150°C	15 minutes	±0.01°C
	150°C to 300°C	25 minutes	±0.05°C
Temperature Uniformity	±0.05°C max between any two points in the test well		
Temperature Accuracy	**Range**	**Accuracy**	
	–100°C to –40°C	±5°C	
	-40°C to 150°C	±1°C	
	150°C to 300°C	±5°C	
Test Well	2.6 inches diameter x 11.3 inches deep (from outlet holes to bottom of well) 60 cubic inches in volume .25 inches deep mercury trap on bottom		

Referigeration (cold tank only)	Two mode system:		
	Single stage	3/4 Hp compressor, R-404a refrigerant, air cooled	
	Two stage (cascade)	Utilizes the single stage unit as high stage of cascade system. 3/4 Hp compressor using ethylene as refrigerant with some propane used to help oil flow in low stage.	
Hot Tank Cooling	Heat loss to ambient cooling used during control. Forced air blown through cavity around bath for lowering temperatures.		
Heating	Hot and cold tanks have position heaters: LOW (250W), MED (500W), HIGH (1,000W)		
Recommended Heat Transfer Fluids	Hot Bath	DOW 710	
	Cold Bath	Halocarbon 0.8	
Exterior Dimensions	Width	45.25 inches	
	Front to back	26.25 inches	
	Height	39 inches to working surface 45 inches to top of motor	
Weight	Unit	450 lbs	
	Shipping	600 lbs	

3 Installation

3.1 Unpacking

Caution is advised in transporting and unpacking the bath. It can be damaged by improper treatment, such as dropping, jolting, or jarring.

Lift the bath by hand carefully from its pallet. Support it from the bottom edge. Because the unit weighs 450 lbs., several people will be needed to lift it. Do not use a fork lift. Once it is set on a level surface, it can easily be rolled into position on its casters.

Verify that all components are present:

- 7013 bath
- Two ambient guards
- Two PRT control probes
- Containers of each fluid
- Two aluminum support posts
- Manual

3.2 Bath Environment

The Model 7013 calibration bath is a precision instrument which must be located in an appropriate environment. The location must be free of drafts, extreme temperatures and temperature changes, dirt, etc. The floor must be level. The area must have low vibration levels and low electrical noise levels.

Do not block air movement into and out of the refrigeration unit at the lower front and rear of the bath as overheating and eventual compressor damage will occur. Allow approximately a foot of free air space for each side of the unit.

The cooling blower vent on the left side of the hot bath (see Figure 5) must also be left clear. When the blower is operating, hot air will be exhausted from this vent into the room (80°C maximum).

3.3 Bath Preparation and Filling

Hart Scientific recommends the following bath fluids:

Hot Bath: Dow 710

Cold Bath : Halocarbon 0.8

The Model 7013 is shipped dry. The heat transfer fluids must be put into the baths before they are used. Remove the pump lid assemblies and inspect. Check the inside of the outer fluid tanks and the test wells for foreign matter. If any is found, remove it to avoid interference with operation.

Warning: Be sure the drain is securely capped before filling (see Figure 7).

Remove the ambient guard. Pour in the heat transfer fluid until it is 4.0 inches from the top for the cold bath or 5.5 inches from the top for the hot bath (see Figure 1). Overfilling may cause tank overflow and slower scan times. Underfilling may reduce bath stability and may possibly damage the heaters. Care should be taken to maintain cleanliness. Use a funnel and immediately clean up spills. Only clean, unpolluted oils should be used. When the bath is filled to the specified level, replace the ambient guard.

Inspect the probes. They should not be bent or damaged in any way. The probes used with the Model 7013 contain precision platinum sensors. They are shock sensitive and must be handled carefully.

Each probe should be plugged into its connector on the rear of the corresponding bath. It is then inserted fully into the hole located near the pump motor on the pump lid assembly. (See Figures 7 and 8.)

Plug each pump power cord into the receptacle located on the rear panel of the bath marked PUMP POWER. These receptacles are switched on with the unit's main power switch.

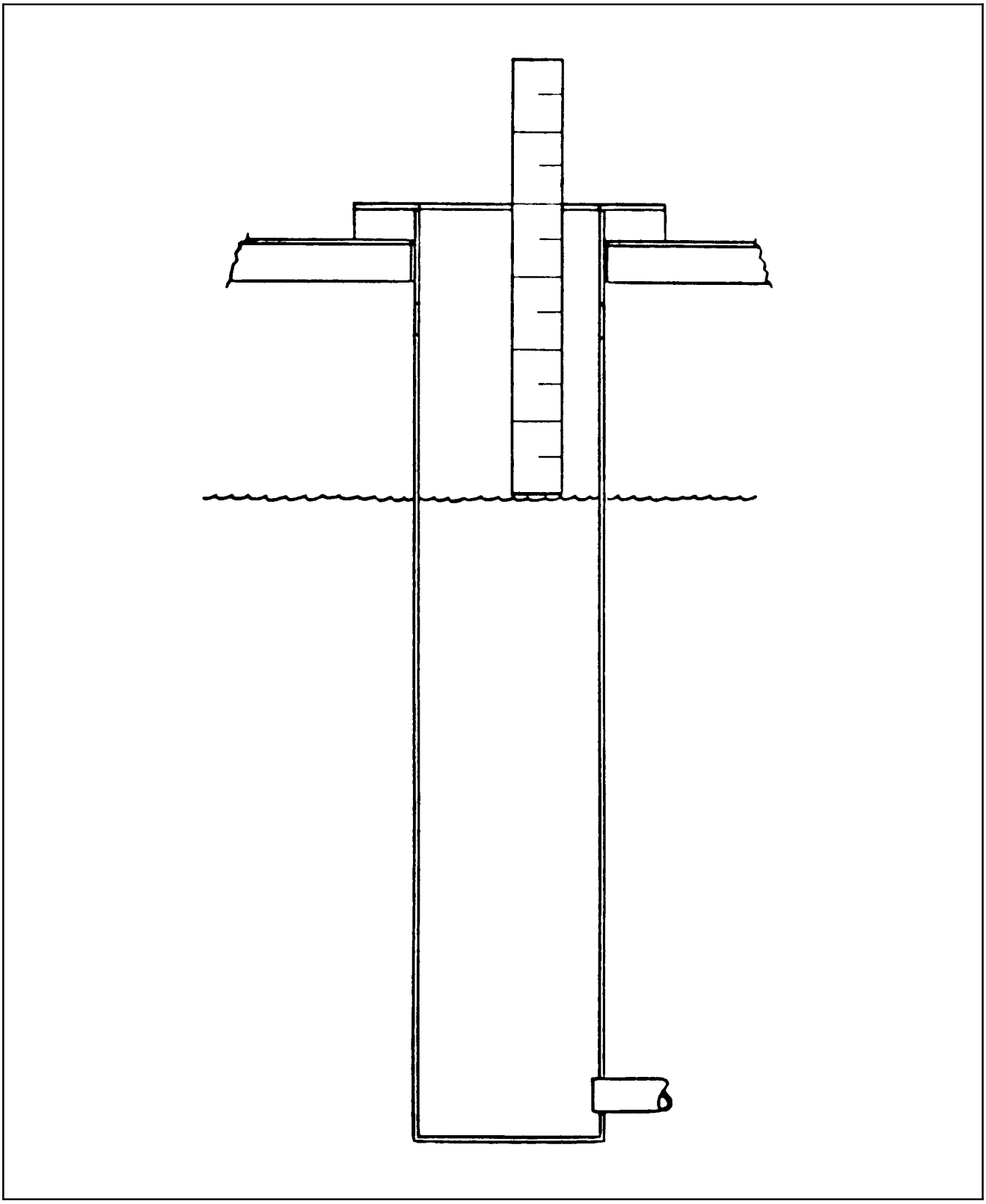

Figure 1. *Heat Exchange Fluids and Levels.*

3.4 Power Requirements

The Model 7013 operates on voltages from 208 to 230 VAC (single phase, 60 Hz).

Warning: An inadequate voltage supply can damage the compressors.

Electrical power is attached to the 7013 in the power box in the back of the unit near the center. Remove the 2.5 x 4.5 inch metal cover to locate three wires. The black wire is the hot line; the white wire the second hot line; and green is ground. Attach these to the power source using wire nuts. Prevent strain on the power cable connections by using the clamp in the box cover. The power line must be capable of supplying 24 amps; use at least 12 gauge wire.

Once the installation is complete, the unit may be operated according to the procedures given in the following sections.

4 Bath System Overview

The Hart Scientific Model 7013 is shown in block form in Figure 2. The bath system consists of two baths. Each bath consists of a (1) tank, (2) pump, (3) test well, (4) temperature controller, (5) control heater, (6) cooling system, (7) overtemperature cutout, (8) bath fluid, and (9) temperature control probe.

The hot bath has an additional heater, referred to as the boost heater, which speeds temperature rise. It also features a cooling blower which blows room temperature air around the tank to rapidly reduce its temperature.

The function of the bath is to provide an accurate and stable temperature medium for calibration of other temperature devices. The bath fluid (8) or oil is the medium to be temperature controlled. It is contained in the tank (1). The fluid is stirred and circulated by the pump (2). This stirring keeps the fluid thermally homogeneous. The fluid is pumped from the tank into the test well (3) and flows out near the top through a series of overflow holes. The test well maintains a constant depth of fluid which is unaffected by thermal expansion or contraction of the fluid.

The bath fluid must be one whose properties of thermal transport, viscosity, boiling and freezing points, flash point, etc., are consistent with the desired temperature range of the bath. The 7013 uses a different fluid in each tank which accomplishes the requirements of its overall range.

The test well (3) is the cylindrical container in which thermal devices are inserted for calibration. **It has a mercury trap in the bottom for catching mercury spills.**

An important part of the test well is the ambient guard. This is the Teflon disk attached to the top of the test well. It prevents excessive heat loss from the surface of the fluid. Holes may be made in the ambient guard to accommodate the needs of individual users. It is important to keep the hole sizes as small as possible so heat loss is reduced. This technique also reduces fluid loss at higher temperatures. Plug unused holes at temperatures where the oil is fuming.

The temperature controller (4) controls the temperature of the bath fluid. The temperature is set by the buttons and digital display on the front panel. The temperature is sensed by the platinum control probe (9) which is inserted into the fluid through the bath lid. The controller's solid-state relay circuit pulses power to the control heaters (5) mounted to the outside wall of the tank. These heaters have three heating power settings: high, medium, and low which are 1,000, 500, and 250 watts respectively. The low and medium positions are used for control while the high position is used only for moving quickly from one temperature to a higher one.

The heaters are protected by fuses. These fuses are located behind the control panels. The bath fluids are protected from reaching temperatures above factory set limits by over-temperature cutouts within the controllers. The hot bath is limited to approximately 310°C and the cold bath to approximately 110°C. They can be programmed to activate at lower temperatures as well. The cutout will be indicated by "cut-out" flashing on the control display when it is tripped. Operation may be resumed by lowering the bath temperature and resetting the cutout.

Cooling is required to offset the heating to maintain constant temperature control. The hot bath is cooled by heat transfer to the air. The cold bath uses refrigeration as its primary cooling source. At temperatures over 50°C, the refrigeration may be turned off since heat loss to the room provides sufficient cooling. The refrigeration system has two modes of operation. It may be either single stage for use from below 50°C to -40°C or two stage cascade for -40°C to -100°C. In the two stage mode, the single stage part of the system becomes the high stage of the two stage cascade system. The high stage cools the condenser of the low stage until it reaches a sufficiently low temperature before the low stage will start. This takes several minutes.

The temperature controller is a precision device which utilizes proportional and integral control circuits. A microprocessor controls the many operation functions of the temperature controller.

The set-point temperature, cutout temperature, and other operating and calibration parameters are set using the front panel buttons and digital display. The control indicator light signals the action of the controller whether it is heating, cooling, or maintaining a constant temperature. It lights red when the heater is on and green when it is off.

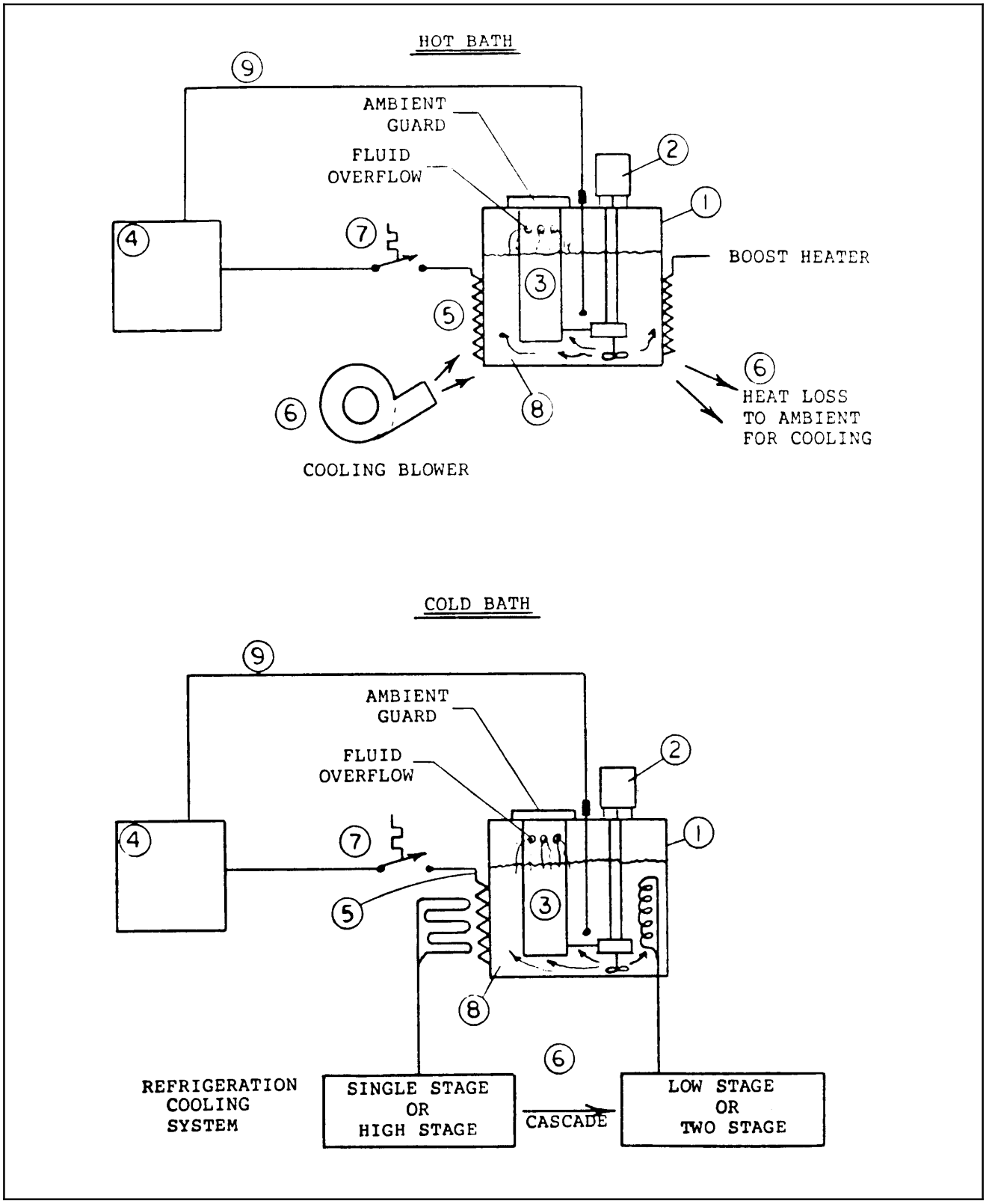

Figure 2. *7013 System Block Diagram*

The hot bath has two features to facilitate scanning its temperature up or down at a higher rate. A boost heater increases the heat input to the bath in order to raise the temperature faster. A cooling blower is provided for lowering the temperature. The cooling blower circulates room air around the outside of the tank. The blower vent at the left rear of the bath must be open when the cooling blower is on for scanning and closed to retain heat for constant temperature control.

5 Description of Parts and Controls

5.1 Temperature Control Panel

The following controls and indicators are present on the controller front panels (see Figure 3 below): (1) the digital LED display, (2) the control buttons, and (3) the control indicator light. Operation of the temperature controller is explained in detail in Section 6.

1) The **digital display** is an important part of the temperature controller. It displays the set-point temperature and bath temperature as well as the various other bath functions, settings, and constants. The display shows temperatures according to the selected scale units C or F.

2) The **control buttons** (SET, DOWN, UP, and EXIT) are used to set the bath temperature setpoint, access and set other operating parameters, and access and set bath calibration parameters.

A brief description of the functions of the buttons follows:

SET ! Used to display the set-point and subsequent parameters in the menus and to set parameters to new values.

DOWN ! Used to decrement the displayed value of parameters.

UP ! Used to increment the displayed value.

EXIT ! Used to exit from a menu. When EXIT is pressed any changes made to the displayed value will be ignored.

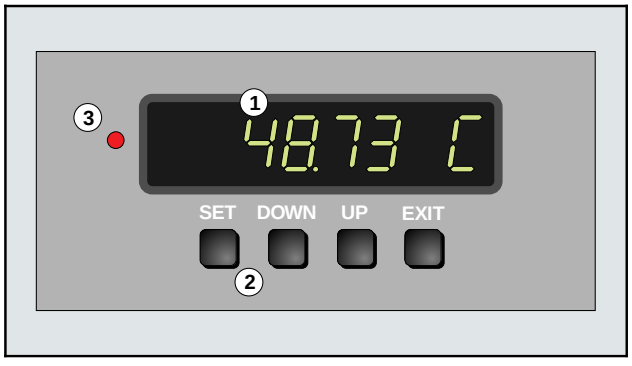

Figure 3. *Temperature Control Panel.*

3) The **control indicator** is a two color light emitting diode (LED). This lets the user visually see the ratio of heating to cooling. When the indicator is red the heater is on, and when it is green the heater is off and the bath is cooling.

5.2 The Control Panels

The control panels (Figure 4) are located at the front of each bath. Each control panel is unique to its bath. Figure 4a shows the control panel for the hot bath while Figure 4b shows the cold bath control panel. Figure 4 c shows the center panel pressure gauge.

5.2.1 Hot Bath Controls

(1) The **Power** switch controls power to the entire hot bath including the controller, heaters, blower and pump circuits.

(2) The **Heater Power** switch has three positions: Low, Medium, and High. Low and Medium are used for control functions while High is used only to raise the bath temperature. The Low, Medium and High positions represent approximately 250, 500 and 1000 watts of heating power respectively.

(3) The **Boost Heater** is used to increase the upward temperature scan rate. This heater is also controlled by the temperature controller so that the controller will stop the temperature rise when the set temperature is reached. This switch must be off for good constant temperature control.

(4) The **Boost Heater Indicator** serves as a reminder that the heater is on. Turn the boost heater off when desired temperature is reached.

(5) The **Cooling Light** shows blue when the blower is on. Turn the blower off when the set temperature is reached.

(6) The **Cooling Blower Switch** turns on the blower that circulates cooler room air around the hot bath tank in order to lower its temperature at a faster rate. When the blower is turned on, the blower vent on the left side near the rear of the

bath (see Figure 5) must be opened. It must be closed again for control. Note: The cooling blower may be used at low temperatures to provide added heat loss for controlling the bath.

5.2.2 Cold Bath Controls

(7) The **Power** switch controls power to the entire cold bath including the controller, heaters, refrigeration and pump circuits.

(8) The **Heater Power** switch, like that on the hot bath, has three positions: Low, Medium, and

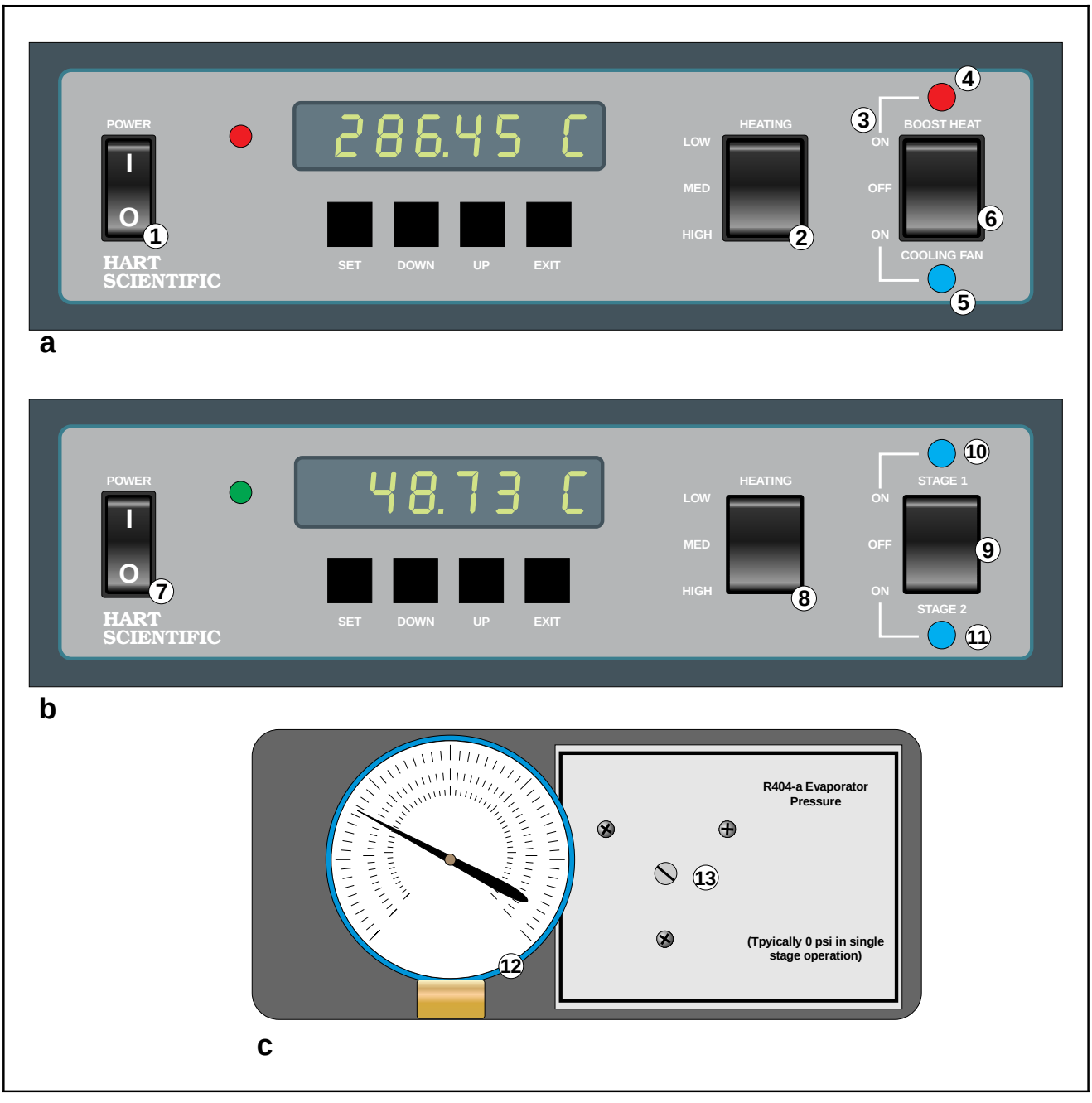

Figure 4. *Power Control Panel.*

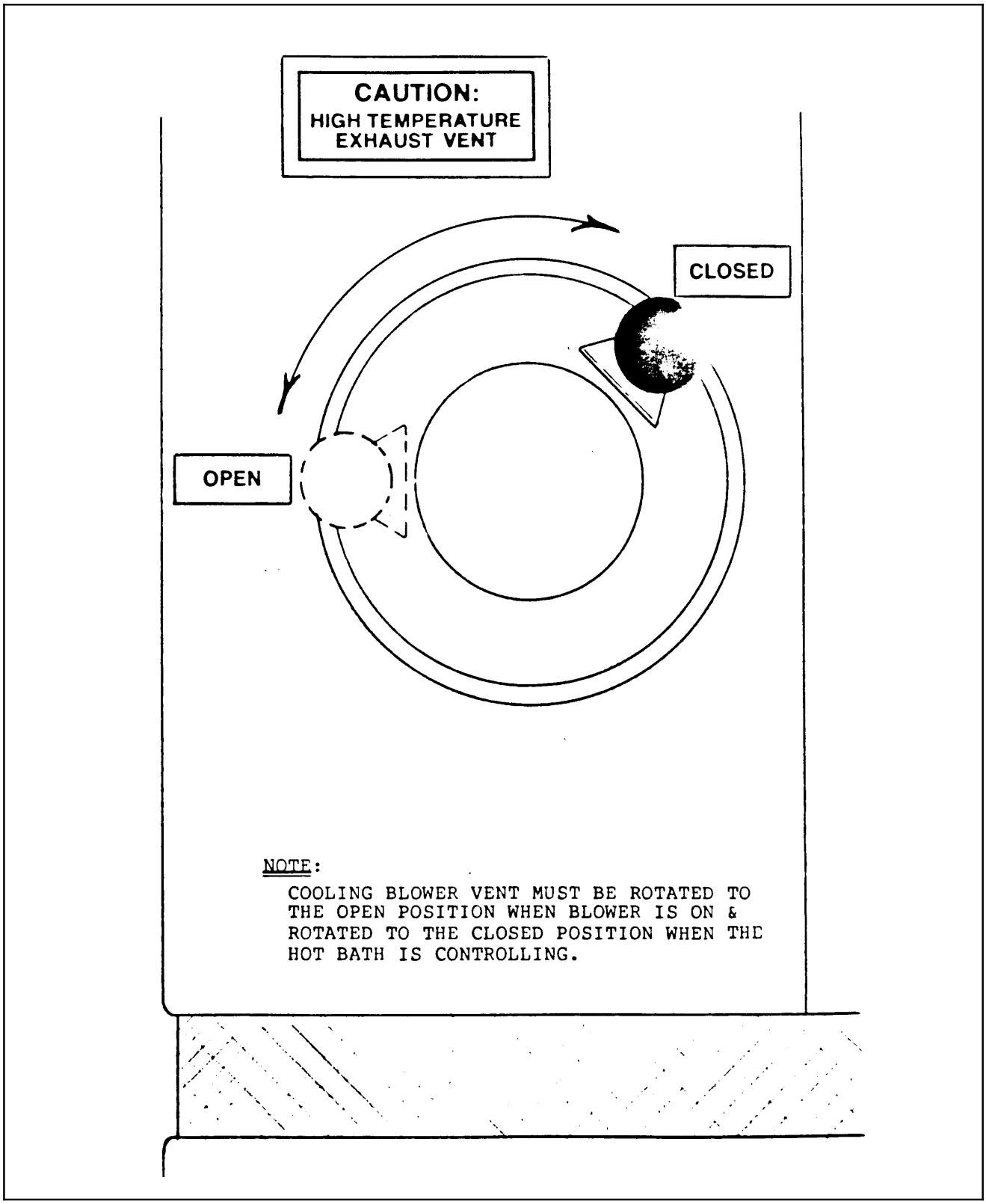
CAUTION:
HIGH TEMPERATURE
EXHAUST VENT
CLOSED
OPEN
NOTE:
COOLING BLOWER VENT MUST BE ROTATED TO THE OPEN POSITION WHEN BLOWER IS ON & ROTATED TO THE CLOSED POSITION WHEN THE HOT BATH IS CONTROLLING.

Figure 5. *Cooling Blower Vent.*

High. Low and Medium are used for control while High is used only for quicker heating. The Low, Medium and High positions represent approximately 250, 500 and 1000 watts of heating power respectively.

(9) The **Refrigeration Mode** switch has three positions. They are STAGE 1, OFF, and STAGE 2. The Stage 1 position turns on only one of the two compressors in the unit. The single stage system is used from –40°C to 70°C. The refrigeration can be turned off above 60°C for higher stability. Two stage operation is used for the lower temperatures below –40°C. With two stage operation the single stage compressor, by means of solenoid valves, becomes the high stage of the system. Its function is to cool the condenser of the low stage which in turn cools the bath. The low stage compressor will not turn on until the high stage has cooled the cascade condenser sufficiently. This takes several minutes if the unit has been off for some time.

(10) The **STAGE 1** light indicates when the single stage compressor is on. The Stage 1 indicator will turn on in either the single or two stage modes.

(11) The **STAGE 2** indicator lights when the low stage or two stage compressor is powered up. It normally takes several minutes of high stage operation before it will start.

(12) The **Pressure Gauge** is located in the center panel of the unit and indicates the evaporator pressure of the single stage refrigeration. It is useful in showing that the system is operating properly in single stage mode. It is not useful in two stage mode.

(13) The **Evaporator Temperature Valve** is used to adjust the cooling temperature of the single stage system. Adjustment is factory set and further adjustment is not normally required. However, it may occasionally need to be readjusted to 0 psi by loosening the lock-nut and resetting it.

5.3 Fluid System

The fluid system of the Model 7013 consists of two parts, one for the cold bath and one for the hot bath. The cold system contains approximately 1.6 gallons of Halocarbon 0.8 heat transfer fluid, while the hot system contains approximately 1.4 gallons of Dow 710 heat transfer fluid. Each fluid will function over the entire range of its respective bath (-100 to 70°C for the cold bath and 60°C to 300°C for the hot bath). Other fluids may be used with varying results. However, when using other fluids care must be taken that it is both safe at its intended temperature and that its viscosity is low (less than 50 centistokes) throughout the temperature range.

Each temperature control system consists of an insulated fluid tank, constant fluid level test well, pump/stirrer, integrated heater and cooler, calibrated temperature control probe, temperature controller and ambient guard.

The stainless steel fluid tank serves as an insulated fluid reservoir for the heat transfer fluid. Heat transfer for heating and cooling takes place in its walls from an integrated heating and cooling unit. This unique design allows for maximum temperature stability with maximum fluid temperature uniformity.

The heat transfer fluid must be well stirred to maintain high stability. This is accomplished with the pump/stirrer which is a combination centrifugal pump and propeller stirrer device. The fluid is pumped from the tank into the test well. It fills the test well until it reaches the overflow holes in the top. The fluid then flows back into the tank. Hence, a constant fluid level is maintained in the test well regardless of fluid expansion, contraction or loss by evaporation.

As the fluid circulates, it passes by the temperature control probe. Temperature deviations from its calibrated set-point are detected by the temperature controller and the needed corrections made to the heating. The cooling provided either by the refrigeration or by heat loss through the tank walls is constant. The temperature controller counters this cooling effect with pulsed power through the resistance heating elements.

The ambient guard (see Figures 6 and 8) may be removed for easy access to the test well. However, in order to maintain high precision control it is important that it be put back in place before operating the bath. Failure to do so may result in decreased temperature stability.

The ambient guard is supplied blank without holes. Holes may be drilled by the user as needed. These holes should be as small as possible or plugged to reduce temperature instability and fluid losses.

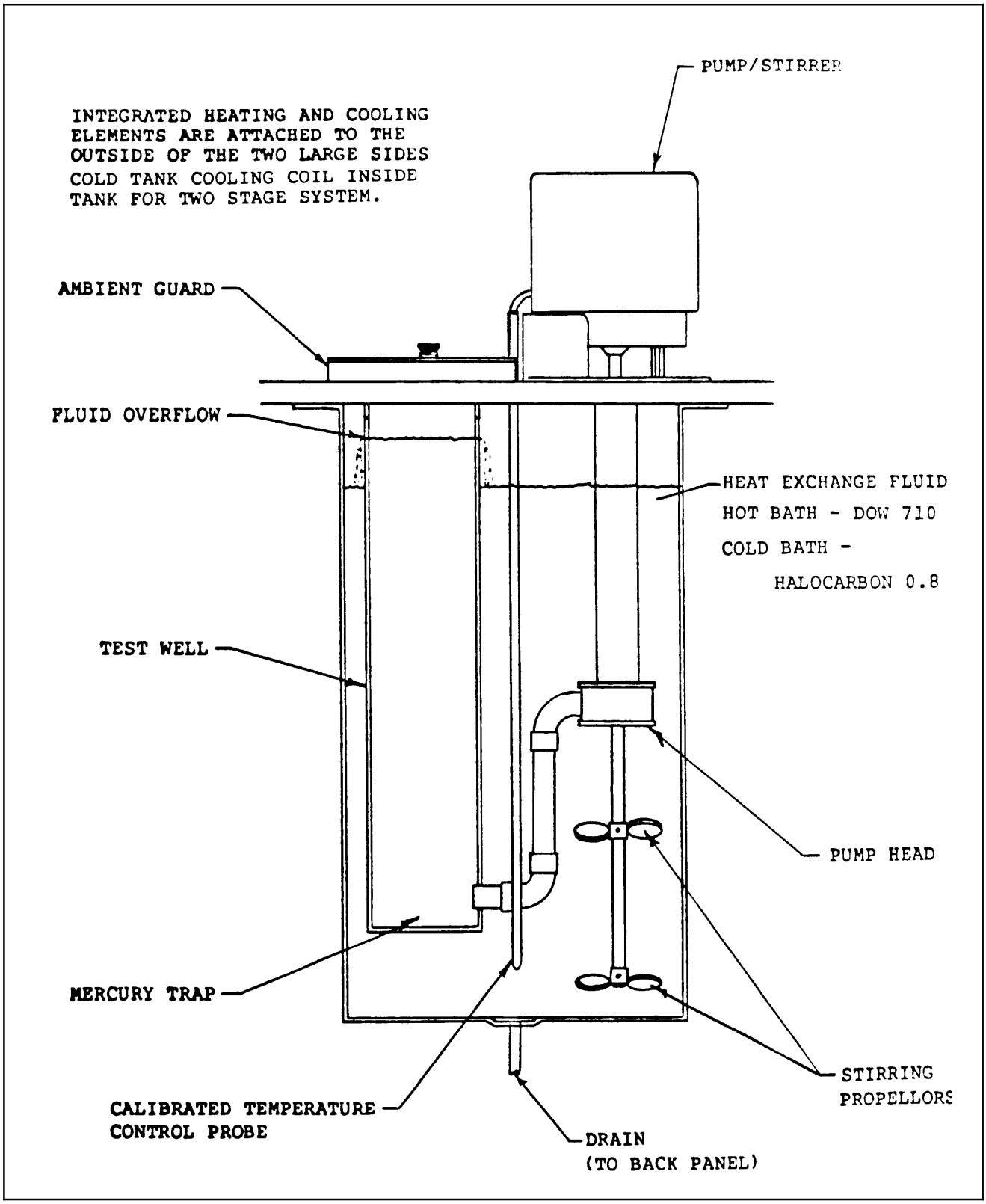

Figure 6. *Fluid System.*

5.4 Back Panel

The following features are located on the back panel of the Model 7013 (see Figure 7). Items 1-3 relate to the cold bath, while items 5-7 relate to the hot bath.

(1) The **Drain** provides an easy way to drain the cold bath tank when either changing fluids or cleaning. To drain the tank, remove the drain cap by turning it counterclockwise. When draining is finished be sure to replace the drain cap, fitting it snugly to insure that the seal is leak-proof.

(2) The **Probe Connector** is used to connect the cold bath control probe to the temperature controller.

(3) The **Pump Power Receptacle** is for the cold bath pump. Its power is turned on with the main power switch. The pump requires 230 VAC.

(4) The **Main Power Box** contains three 12 gauge wires. This supplies power to both the cold and hot baths. The white and black wires are the two hot legs of the 230 VAC power supply and the green wire is ground.

(5) This **Pump Power Receptacle** is for the hot bath pump. Its power is turned on with the main power switch. The pump requires 230 VAC.

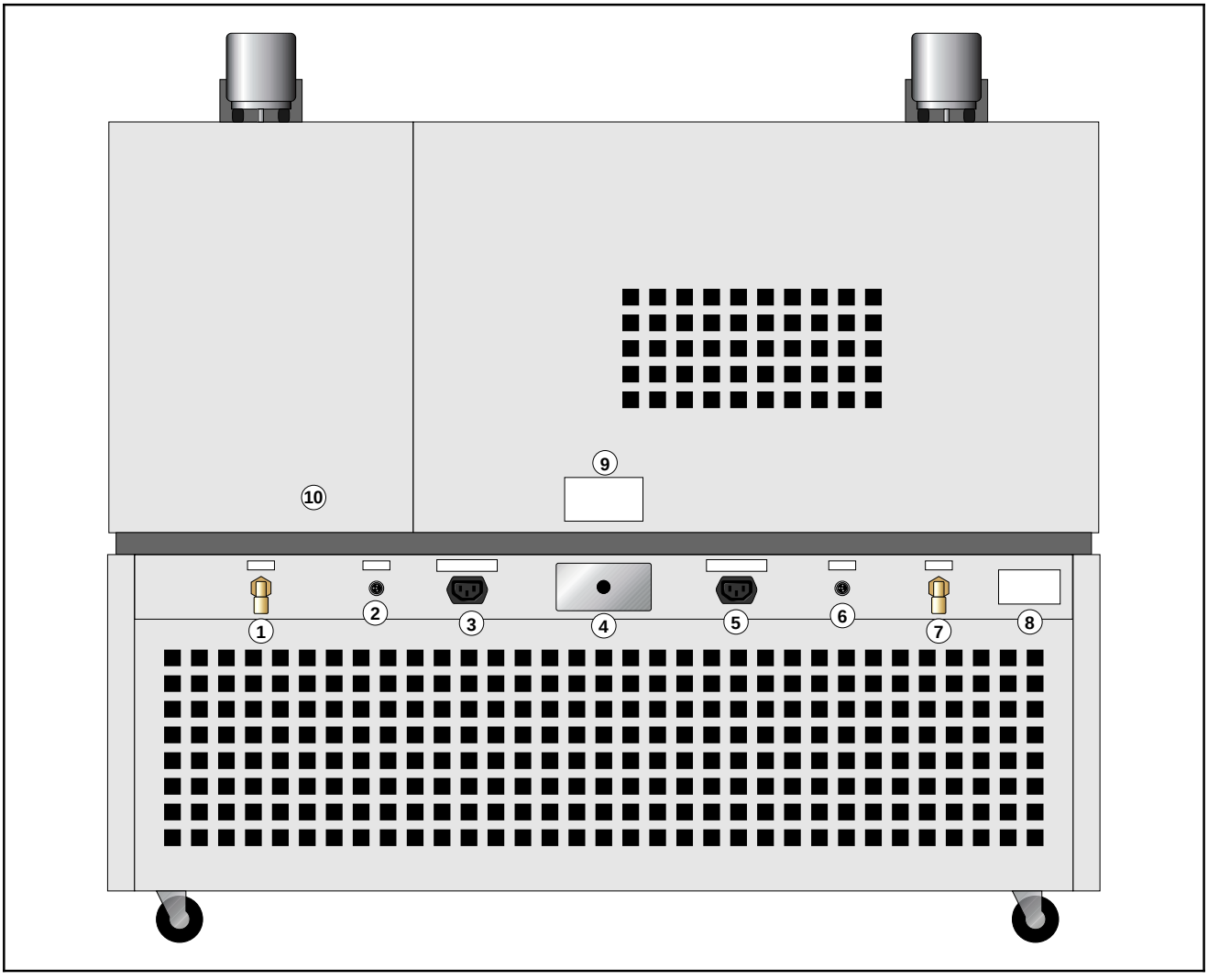

Figure 7. *Back panel.*

(6) This **Probe Connector** is used to connect the hot bath control probe to the temperature controller.

(7) This **Drain** is used to empty the hot bath. Be sure to allow fluids to cool to safe temperatures before draining.

(8) The **Serial Number Label** identifies the bath for reference when contacting the factory.

(9) The **Power Requirement Label** specifies the electrical power to be connected to the unit.

(10) The **System Fuses** for both baths are located inside the back panel. The fuses are rated at 250 VAC, 15 Amp slow blow. If the fuses need to be replaced, be sure to use fuses with equivalent ratings.

5.5 Pump Lid Assembly

The pump lid assembly on each bath consists of the lid, test well, pump/stirrer assembly, ambient guard, probe, probe clamp, and lid clamping screws. See Figure 8.

The lid is made of brushed stainless steel for protection against corrosion. The test well, pump/stirrer, etc. attach to the lid to make a single unit which is attached and fixed in location by the four lid clamping screws located on the sides of each lid. The lid is

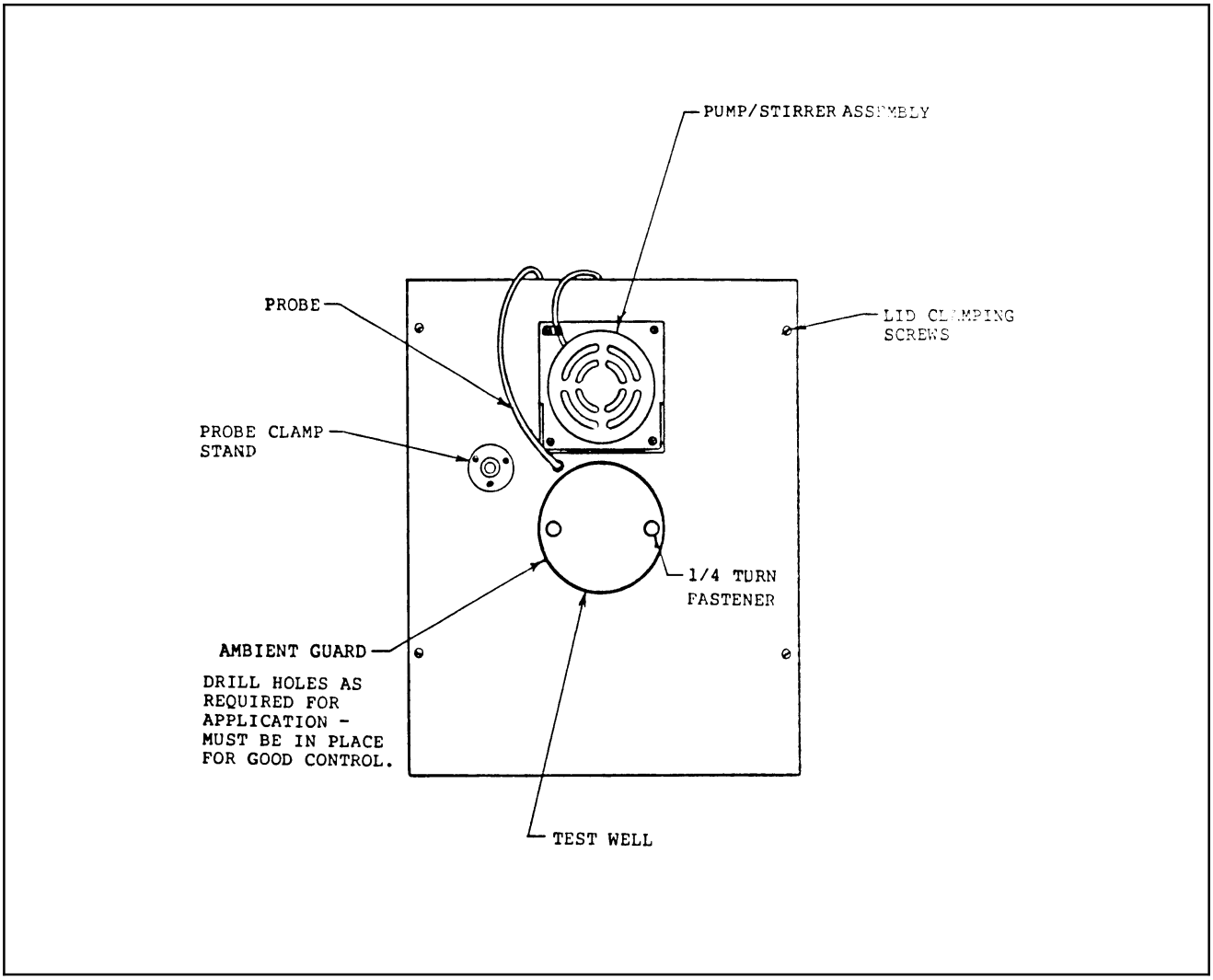

Figure 8. *Pump Lid Assembly.*

sealed against the tank with a teflon gasket. The lid is insulated to protect the fluid from the ambient temperature.

The test well provides the temperature controlled chamber for calibration of immersion type temperature devices. A constant fluid level is maintained in this device by the pump. This fluid reduces stem effects and always provides an immersion depth of 11.3 inches. The bottom ¼ inch of the test well serves as a mercury trap. If mercury bulbs are inadvertently broken, the mercury will fall into this cavity. The pump lid assembly may then be removed and the mercury dumped out. Note that this design prevents the probe being calibrated from coming in contact with any stirring, heating, cooling, or temperature sensing elements.

Warning: Use of the cold bath for long periods at low temperatures may produce sufficient ice buildup to block the overflow holes.

To prevent fluid loss and damage due to fluid escaping the test well, occasionally check the system and remove ice. To remove accumulated water raise the bath temperature to over 100°C but do not operate at this temperature for too long or too much of the heat transfer fluid may also evaporate.

The pump stirrer assembly both circulates the heat exchange fluid through the test well and stirs it within the tank. Proper mixing of the fluid is essential for good constant temperature control. The pump is powered by a 230 volt 60 Hz 1,500 RPM motor.

The ambient guard is mounted above the test well with two ¼ turn thumbscrews. It is easily removed for inspection of fluid levels (with the pump power off). It consists of a Teflon disk with the screw assemblies attached on opposite sides. Teflon is used because of its temperature and chemical resistance. The ambient guard reduces room temperature effects on the heat transfer fluid and also reduces evaporation.

The probe is inserted up to the hub into the hole indicated. It must be in place for the bath to control. Not having the probe in place could be a hazard both to the bath and devices placed in it for calibration. Without the probe in the fluid or plugged in, the bath may overheat. The over-temperature cutouts are designed to help prevent damage from such conditions.

Warning: Never operate the bath without the probes inserted in the wells and connected to the controller or without the wells filled with fluids.

A probe clamp stand is provided to hold devices such as SPRTs, probes being calibrated, etc. It consists of a ½ inch diameter post mounted in a base on the bath lid. A clamp may be attached to it and adjusted to hold the desired instrument in a fixed position.

The lid clamping screws are to be tightened snugly but not over-tightened or the lid could be damaged. Standoffs on the tank side stop the travel of the lid as it is tightened and keep it level.

6 General Operation

This chapter contains general information on how the bath is operated such as how to set the temperature and how to adjust the controls. Operation of the temperature controller is explained in more detail in the next chapter. It is assumed that the bath has been properly connected to AC power, the wells filled with fluids, and the probes placed and connected as explained in Chapter 3 on installation. The user should also be familiar with all the controls and features and their functions as described in Chapter 5.

The user must keep in mind a few precautions. Check the fluid regularly to make sure the level is correct. Heaters may be damaged if the fluid level is too low. Too much fluid may cause overflow.

CAUTION: Heaters may be damaged if the fluid level is too low. Check the fluid level regularly.

Also make sure the fluid is being circulated properly. This is important to maintain a constant temperature in the tank. If ice or other foreign matter builds up in the wells the orifices may become blocked causing poor circulation or overflow. If excessive water or ice accumulates in the cold bath it may be removed by raising the temperature of the bath above 100°C until the moisture boils off. Do not operate at this temperature for too long or much of the heat transfer fluid may be lost by evaporation.

WARNING: Use of the cold bath for long periods at low temperatures may produce sufficient ice buildup to block the overflow holes. Occasionally check the system and remove ice.

6.1 Power Up

Turn on the hot bath or cold bath with the power switch. The digital display will initialize and begin to display the temperature. The temperature controller will begin to heat or cool the bath to reach the programmed set-point. The set-point can be changed to a new temperature if desired.

6.2 Setting the Temperature

In the following discussion a solid box around the word SET, UP, DOWN or EXIT indicates the panel button to press while the dotted box indicates the display reading on the front panel. Explanation of the button function or display reading is written at the right.

To view or change the set-point proceed as follows.

The front panel LED display normally shows the actual bath temperature.

24.68 C	*Bath temperature display*

When SET is pressed the display will show the set-point memory that is currently being used and its value. Eight set-point memories are available.

SET	*Access set-point selection*
1. 25.0	*Set-point 1, 25.0C currently used*

Press SET to select this memory and access the set-point value.

SET	*Access set-point value*
C 25.00	*Current value of set-point 1, 25.00C*

Press UP or DOWN to change the set-point value.

UP	*Increment display*
C 50.00	*New set-point value*

Press SET to accept the new value and display the vernier value. The bath begins heating or cooling to the new set-point.

SET	*Store new set-point, access vernier*

0.00000 *Current vernier value*

Press EXIT and the bath temperature will be displayed again.

EXIT *Return to the temperature display*

24.73 C *Bath temperature display*

The bath will heat or cool until it reaches the new set-point temperature. The control indicator indicates the action of the controller.

6.3 Control Indicator

The control indicator light shows whether the bath is heating or cooling. When the light glows green the bath temperature is higher than the set-point and the bath requires cooling. When the light is red the temperature is lower than the set-point and the controller is attempting to heat the bath. When the temperature reaches the set-point the light will quickly alternate between red and green as the heater turns on and off to maintain the proper amount of heat.

Indicator color	Control action
Green	Cooling
Red	Heating
Flashing	Controlling

6.4 Hot Bath Controls

The heating controls may require adjustment to more quickly reach the desired temperature when the set-point is changed. The following chart shows what the heating switches should be set to depending on the required temperature change.

Temperature change	Controls
< –2°C	Blower on
–2 to +4°C	Low or Medium heater
> +4°C	High or Boost heater

When cooling in excess of 1 or 2°C is required, open the blower vent (see Figure 5 and Section 5.2.1) on the left side of the bath and then turn on the blower. When the desired temperature is reached, turn the blower off, close the blower vent, and switch the heater power to Low or Medium. Select the recommended heater power from the following chart depending on the temperature.

Temperature range	Heater Power
60 to 200°C	Low
200 to 300°C	Med

6.5 Cold Bath Controls

The following chart shows what the cold bath controls should be set to depending on the required temperature change.

Range and Temperature Change	Heater Power	Cooling Mode
range –100°C to –40°C		
change < +4°C	Low or Med	Two Stage
change > +4°C	High	Two Stage
change > +10°C	High	Single Stage
range –40°C to 70°C		
change < –4°C	Low or Med	Two Stage
change –4 to +4°C	Low or Med	Single Stage
change > +4°C	High	Single Stage

When the desired temperature is reached set the heating and refrigeration controls to maintain a constant temperature. The recommended settings are shown on the following chart.

Temperature	Heater Power	Refrigeration
–100 to –60°C	Low	Two Stage
–60 to –40°C	Med	Two Stage
–40 to 0°C	Low	Single Stage
0 to 60°C	Med	Single Stage
above 60°C	Low	Off

6.6 Controller Adjustments

When the bath reaches the set-point temperature allow another 10 to 15 minutes for the temperature to stabilize. The control indicator will flash at a constant rate when the temperature reaches the set- point. The heating power may be viewed on the digital display to verify that the temperature is steady. This is explained in Section 7.6 in the next chapter. To obtain optimum control stability the controller proportional band may be adjusted as discussed in Section 7.7.

If fine adjustment of the temperature is needed the digital vernier control can be set (see Section 7.3.3). When setting the set-point temperature be careful not to exceed the temperature limit of the bath, fluid, or devices placed in the bath. The over-temperature cutout should be correctly set to help protect against excessive temperature (see Section 7.8).

7 Controller Operation

This chapter discusses in detail how to operate the hot bath or cold bath temperature controller using the front control panel. The user may monitor the bath temperature, set the temperature set-point in degrees C or F, monitor the heater output power, adjust the controller proportional band, set the cutout set-point, and program the probe calibration parameters, operating parameters, and controller calibration parameters.

Functions are separated into groups called menus. The primary menu contains the most often used functions. These are the temperature display, cutout reset, set-point memory, set-point, vernier, and units selection. The primary menu is outlined in Figure 9.

7.1 Bath temperature

The digital LED display on the front panel allows direct viewing of the actual bath temperature. This temperature value is what is normally shown on the display. The units, C or F, of the temperature value are displayed at the right. For example,

`25.00 C` *Bath temperature in degrees Celsius*

The temperature display function may be accessed from any other function by pressing the “EXIT” button.

7.2 Reset Cutout

If the over-temperature cutout has been triggered then the temperature display will alternately flash “`cutout`”.

`cutout` *Indicates cut-out condition*

The message will continue to flash until the temperature is reduced and the cutout is reset.

The cutout has two modes — automatic reset and manual reset. The mode determines how the cutout is reset which allows the bath to heat up again. When in automatic mode, the cutout will reset itself as soon as the temperature is lowered below the cutout set-point. With manual reset mode the cutout must be reset by the operator after the temperature falls below the set-point.

When the cutout is active and the cutout mode is set to manual (“reset”) then the display will flash “cutout” until the user resets the cutout. To access the reset cutout function press the “SET” button.

SET *Access cutout reset function*

The display will indicate the reset function.

`rESEt ?` *Cutout reset function*

Press “SET” once more to reset the cutout.

SET *Reset cutout*

This will also switch the display to the set temperature function. To return to displaying the temperature press the “EXIT” button. If the cutout is still in the over-temperature fault condition the display will continue to flash “cutout”. The bath temperature must drop a few degrees below the cutout set-point before the cutout can be reset.

7.3 Temperature Set-point

The bath temperature can be set to any value within the range and with resolution as given in the specifications. The temperature range of the particular fluid used in the bath must be known by the operator and the bath should only be operated well below the upper temperature limit of the liquid. In addition, the cutout temperature should also be set below the upper limit of the fluid.

Setting the bath temperature involves three steps: (1) select the set-point memory, (2) adjust the set-point value, and (3) adjust the vernier if desired.

7.3.1 Programmable Set-points

The controller stores 8 set-point temperatures in memory. The set-points can be quickly recalled to

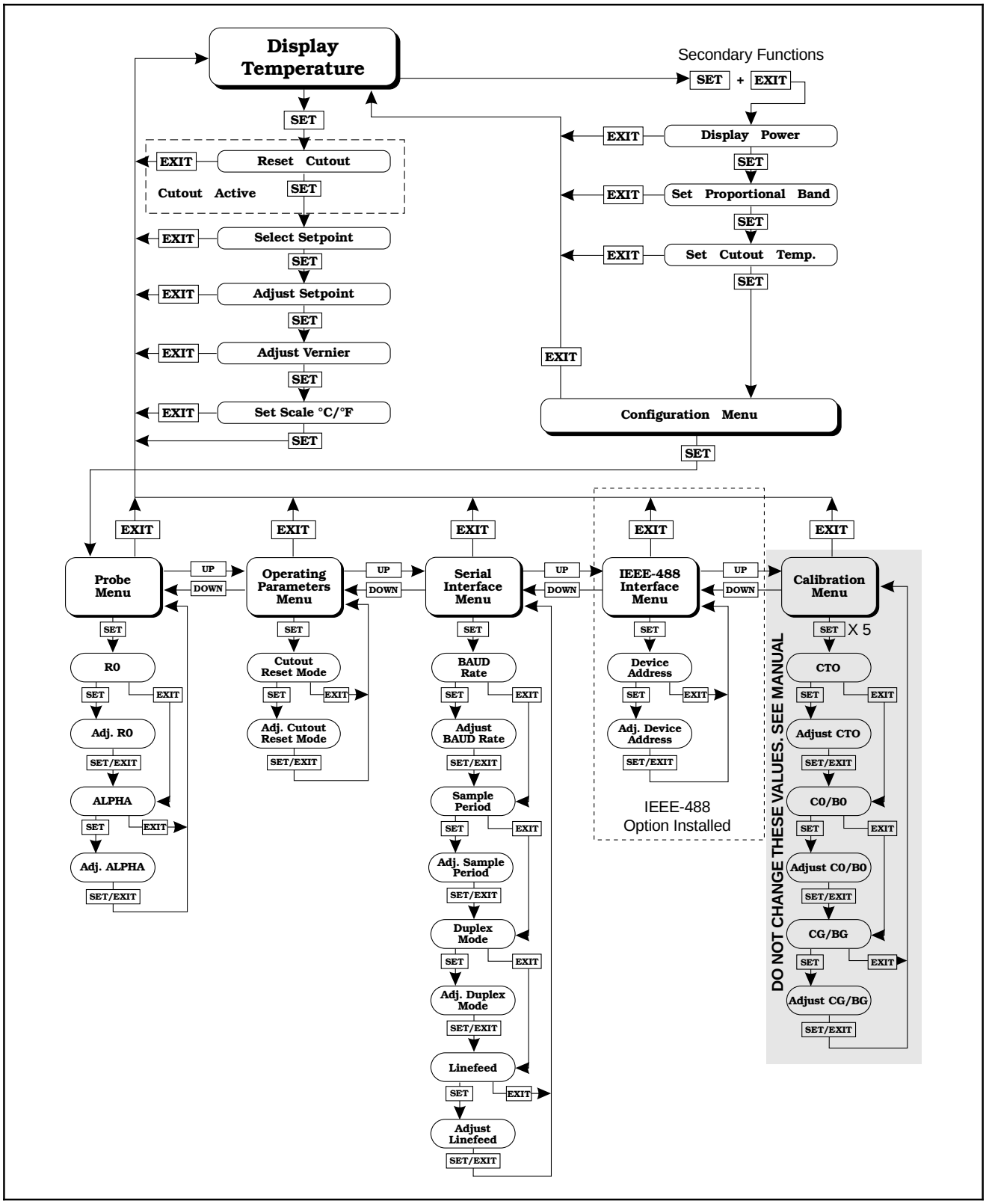

Figure 9. *Controller Operation Flowchart.*

conveniently set the bath to a previously programmed temperature.

To set the bath temperature one must first select the set-point memory. This function is accessed from the temperature display function by pressing “SET”. The number of the set-point memory currently being used is shown at the left on the display followed by the current set-point value.

25.00 C *Bath temperature in degrees Celsius*

SET *Access set-point memory*

1. 25.0 *Set-point memory 1, 25.0°C currently used*

To change the set-point memory press “UP” or “DOWN”.

4. 40.0 *New set-point memory 4, 40.0°C*

Press “SET” to accept the new selection and access the set-point value.

SET *Accept selected set-point memory*

7.3.2 Set-point Value

The set-point value may be adjusted after selecting the set-point memory and pressing “SET”. The set-point value is displayed with the units, C or F, at the left.

C 40.00 *Set-point 4 value in °C*

If the set-point value need not be changed then press “EXIT” to resume displaying the bath temperature. To adjust the set-point instead press “UP” or “DOWN”.

C 42.50 *New set-point value*

When the desired set-point value is reached press “SET” to accept the new value and access the set-point vernier. If “EXIT” is pressed instead then any changes made to the set-point will be ignored.

SET *Accept new set-point value*

7.3.3 Set-point vernier

The set-point value can only be set with a resolution of 0.01°C. The user may want to adjust the set-point slightly to achieve a more precise bath temperature. The set-point vernier allows one to adjust the temperature below or above the set-point by a small amount with very high resolution. Each of the 8 stored set-points has an associated vernier setting. The vernier is accessed from the set-point by pressing “SET”. The vernier setting is displayed as a 6 digit number with five digits after the decimal point. This is a temperature offset in degrees of the selected units, C or F.

0.00000 *Current vernier value in °C*

To adjust the vernier press “UP” or “DOWN”. Unlike most functions the vernier setting has immediate effect as the vernier is adjusted. “SET” need not be pressed. This allows one to continually adjust the bath temperature with the vernier as it is displayed.

0.00090 *New vernier setting*

Next press “EXIT” to return to the temperature display or “SET” to access the temperature scale units selection.

SET *Access scale units*

7.4 Temperature Scale Units

The temperature scale units of the controller may be set by the user to degrees Celsius (°C) or Fahrenheit (°F). The units will be used in displaying the bath temperature, set-point, vernier, proportional band, and cutout set-point.

The temperature scale units selection is accessed after the vernier adjustment function by pressing “SET”. From the temperature display function access the units selection by pressing “SET” 4 times.

25.00 C *Bath temperature*

SET *Access set-point memory*

1. 25.0 *Set-point memory*

SET *Access set-point value*

C 25.00 *Set-point value*

SET *Access vernier*

0.00000 *Vernier setting*

SET *Access scale units selection*

Un= C *Scale units currently selected*

Press “UP” or “DOWN” to change the units.

Un= F *New units selected*

Press “SET” to accept the new selection and resume displaying the bath temperature.

SET *Set the new units and resume temperature display*

7.5 Secondary Menu

Functions which are used less often are accessed within the secondary menu. The secondary menu is accessed by pressing SET and EXIT simultaneously and then releasing. The first function in the secondary menu is the heater power display. (See Figure 10.)

7.6 Heater Power

The temperature controller controls the temperature of the bath by pulsing the heater on and off. The total power being applied to the heater is determined by the duty cycle or the ratio of heater on time to the pulse cycle time. This value may be estimated by watching the red/green control indicator light or read directly from the digital display. By knowing the amount of heating the user can tell if the bath is heating up to the set-point, cooling down, or controlling at a constant temperature. Monitoring the percent heater power will let the user know how stable the bath temperature is. With good control stability the percent heating power should not fluctuate more than ±1% within one minute.

The heater power display is accessed in the secondary menu. Press “SET” and “EXIT” simultaneously and release. The heater power will be displayed as a percentage of full power.

SET + EXIT *Access heater power in secondary menu*

12 Pct *Heater power in percent*

To exit out of the secondary menu press “EXIT”. To continue on to the proportional band setting function press “SET”.

7.7 Proportional Band

In a proportional controller such as this the heater output power is proportional to the bath temperature over a limited range of temperatures around the set-point. This range of temperature is called the proportional band. At the bottom of the proportional band the heater output is 100%. At the top of the proportional band the heater output is 0. Thus as the bath temperature rises the heater power is reduced, which consequently tends to lower the temperature back down. In this way the temperature is maintained at a constant temperature.

The temperature stability of the bath depends on the width of the proportional band. See Figure 10. If the band is too wide the bath temperature will deviate excessively from the set-point due to varying external conditions. This is because the power output changes very little with temperature and the controller cannot respond very well to changing conditions or noise in the system. If the proportional band is too narrow the bath temperature may swing back and forth because the controller overreacts to temperature variations. For best control stability the proportional band must be set for the optimum width.

The proportional band should be wider when the higher power settings are used. The proportional band may also require adjustment depending on the fluid, temperature, and application of the bath.

The proportional band width is easily adjusted from the front panel. The width may be set to discrete values in degrees C or F depending on the selected units. The optimum proportional band width setting may be determined by monitoring the stability with a high resolution thermometer or with the controller

percent output power display. Narrow the proportional band width to the point at which the bath temperature begins to oscillate and then increase the band width from this point by 3 or 4 times. Typically the optimum proportional band is about .2°C with low heater power and .4°C with medium heater power.

The proportional band adjustment may be accessed within the secondary menu. Press SET and EXIT to enter the secondary menu and show the heater power. Then press SET to access the proportional band.

SET + EXIT *Access heater power in secondary menu*

12 Pct *Heater power in percent*

SET *Access proportional band*

Pb=0.429C *Proportional band setting*

To change the proportional band press UP or DOWN.

DOWN *Decrement display*

Pb=0.204C *New proportional band setting*

To accept the new setting and access the cutout set-point press SET. Pressing EXIT will exit the secondary menu ignoring any changes just made to the proportional band value.

SET *Accept the new proportional band setting*

7.8 Cutout

As a protection against software or hardware fault, shorted heater triac, or user error, the bath is equipped with an adjustable heater cutout device that will shut off power to the heater if the bath temperature exceeds a set value. This protects the heater, fluid, bath materials, and user's devices from excessive temperatures. The cutout temperature is programmable by the operator from the front panel of the controller. The cutout can be set to any temperature between 0°C and the upper limit of the bath.

If the cutout is activated because of excessive bath temperature then power to the heater will be shut off and the bath will cool. The bath will cool until it reaches a few degrees below the cutout set-point

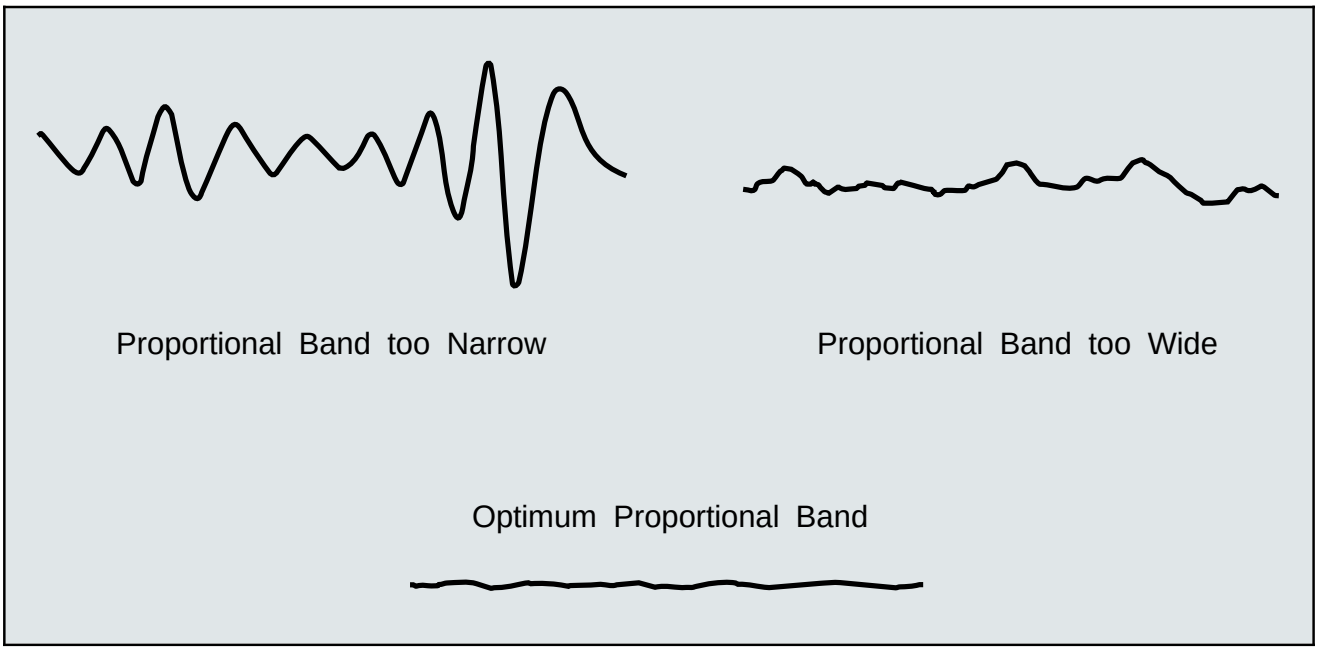

Figure 10. *Proportional Band.*

temperature. At this point the action of the cutout is determined by the setting of the cutout mode parameter. The cutout has two modes — automatic reset or manual reset. If the mode is set to automatic, then the cutout will automatically reset itself when the bath temperature falls below the reset temperature allowing the bath to heat up again. If the mode is set to manual, then the heater will remain disabled until the user manually resets the cutout.

The cutout set-point may be accessed within the secondary menu. Press SET and EXIT to enter the secondary menu and show the heater power. Then press SET twice to access the cutout set-point.

SET + EXIT *Access heater power in secondary menu*

12 PcE *Heater power in percent*

SET *Access proportional band*

Pb=0.204C *Proportional band setting*

SET *Access cutout set-point*

C0= 110C *Cutout set-point*

To change the cutout set-point press UP or DOWN.

DOWN *Decrement display*

C0= 75C *New cutout set-point*

To accept the new cutout set-point press SET.

SET *Accept cutout set-point*

The next function is the configuration menu. Press EXIT to resume displaying the bath temperature.

7.9 Controller Configuration

The controller has a number of configuration and operating options and calibration parameters which are programmable via the front panel. These are accessed from the secondary menu after the cutout set-point function by pressing “SET”. There are 4 sets of configuration parameters — probe parameters, operating parameters, serial interface parameters, and controller calibration parameters. The serial interface parameters are only used with baths that are equipped with a serial interface. The menus are selected using the “UP” and “DOWN” keys and then pressing “SET”.

7.10 Probe Parameters Menu

The probe parameter menu is indicated by :

PrObE *Probe parameters menu*

Press “SET” to enter the menu. The probe parameters menu contains the parameters, R0 and ALPHA, which characterize the resistance-temperature relationship of the platinum control probe. The probe parameters are accessed by pressing “SET” after the name of the parameter is displayed. The value of the parameter may be changed using the “UP” and “DOWN” buttons. After the desired value is reached press “SET” to set the parameter to the new value. Pressing “EXIT” will cause the parameter to be skipped ignoring any changes that may have been made.

7.10.1 R0

This probe parameter refers to the resistance of the control probe at 0°C. Normally this is set for 100.000 ohms.

7.10.2 ALPHA

This probe parameter refers to the average sensitivity of the probe between 0 and 100°C. Normally this is set for 0.00385°C^{-1}.

7.11 Operating Parameters

The operating parameters menu is indicated by:

PAr *Operating parameters menu*

Press “SET” to enter the menu. The operating parameters menu contains the cutout reset mode setting.

7.11.1 Cutout Reset Mode

The cutout reset mode determines whether the cutout resets automatically when the bath temperature drops to a safe value or must be manually reset by the operator.

The parameter is indicated by:

`CtorSt` *Cutout reset mode parameter*

Press “SET” to access the parameter setting. Normally the cutout is set for automatic mode.

`Cto=Auto` *Cutout set for automatic reset*

To change to manual reset mode press “UP” and then “SET”.

`Cto=rSt` *Cutout set for manual reset*

7.12 Serial Interface Parameters

The serial interface parameters are only used with baths that are equipped with a serial interface. The serial RS-232 interface parameters menu is indicated by:

`SErIAL` *Serial RS-232 interface parameters menu*

The serial interface parameters menu contains parameters which determine the operation of the serial interface. These controls only apply to controllers fitted with the serial interface. The parameters in the menu are — BAUD rate, sample period, duplex mode, and linefeed.

7.12.1 BAUD Rate

The BAUD rate is the first parameter in the menu. The BAUD rate setting determines the serial communications transmission rate.

The BAUD rate parameter is indicated by:

`BAUd` *Serial BAUD rate parameter*

Press “SET” to choose to set the BAUD rate. The current BAUD rate value will then be displayed.

`1200 b` *Current BAUD rate*

The BAUD rate of the serial communications may be programmed to 300,600,1200, or 2400 BAUD. Use “UP” or “DOWN” to change the BAUD rate value.

`2400 b` *New BAUD rate*

Press “SET” to set the BAUD rate to the new value or “EXIT” to abort the operation and skip to the next parameter in the menu.

7.12.2 Sample Period

The sample period is the next parameter in the serial interface parameter menu. The sample period is the time period in seconds between temperature measurements transmitted from the serial interface. If the sample rate is set to 5 for instance then the controller will transmit the current measurement over the serial interface approximately every five seconds. The automatic sampling is disabled with a sample period of 0. The sample period is indicated by:

`SAMPLE` *Serial sample period parameter*

Press “SET” to choose to set the sample period. The current sample period value will be displayed.

`SA= 1` *Current sample period (seconds)*

Adjust the value with “UP” or “DOWN” and then use “SET” to set the sample rate to the displayed value.

`SA= 60` *New sample period*

7.12.3 Duplex Mode

The next parameter is the duplex mode. The duplex mode may be set to full duplex or half duplex. With full duplex any commands received by the controller via the serial interface will be immediately echoed or transmitted back to the device of origin. With half duplex the commands will be executed but not echoed. The duplex mode parameter is indicated by:

`dUPL` *Serial duplex mode parameter*

Press “SET” to access the mode setting.

dUP=FULL *Current duplex mode setting*

The mode may be changed using “UP” or “DOWN” and pressing “SET”.

dUP=HALF *New duplex mode setting*

7.12.4 Linefeed

The final parameter in the serial interface menu is the linefeed mode. This parameter enables (on) or disables (off) transmission of a linefeed character (LF, ASCII 10) after transmission of any carriage-return. The linefeed parameter is indicated by:

LF *Serial linefeed parameter*

Press “SET” to access the linefeed parameter.

LF= On *Current linefeed setting*

The mode may be changed using “UP” or “DOWN” and pressing “SET”.

LF= OFF *New linefeed setting*

7.13 IEEE-488 Parameters Menu

Controllers may optionally be fitted with an IEEE-488 GPIB interface. In this case the user may set the interface address within the IEEE-488 parameter menu. This menu does not appear on instruments not fitted with the interface. The menu is indicated by:

IEEE *IEEE-488 parameters menu*

Press “SET” to enter the menu.

7.13.1 IEEE-488 Address

The IEEE-488 interface must be configured to use the same address as the external communicating device. The address is indicated by:

AddrESS *IEEE-488 interface address*

Press “SET” to access the address setting.

Add= 22 *Current IEEE-488 interface address*

Adjust the value with “UP” or “DOWN” and then use “SET” to set the address to the displayed value.

Add= 15 *New IEEE-488 interface address*

7.14 Calibration Parameters

The operator of the bath controller has access to a number of the bath calibration constants namely CTO, B0, BG, H, and L for the cold bath and CTO, C0, CG, H, and L for the hot bath. These values are set at the factory and must not be altered. The correct values are important to the accuracy and proper and safe operation of the bath. Access to these parameters is available to the user only so that in the event that the controller’s memory fails the user may restore these values to the factory settings. The user should have a list of these constants and their settings with the manual.

DO NOT change the values of the bath calibration constants from the factory set values. The correct setting of these parameters is important to the safety and proper operation of the bath.

The calibration parameters menu is indicated by:

CAL *Calibration parameters menu*

Press “SET” five times to enter the menu.

7.14.1 CTO

Parameter CTO sets the calibration of the over-temperature cutout. This is not adjustable by software but is adjusted with an internal potentiometer. For the cold bath this parameter should read between 110°C and 130°C. For the hot bath this parameter should read between 310°C and 330°C.

7.14.2 B0, BG, C0 and CG

These parameters calibrate the accuracy of the bath set-point.

B0 and BG appear with the cold bath and C0 and CG appear with the hot bath. These are programmed at the factory when the bath is calibrated. Do not alter the value of these parameters.

7.14.3 H and L

These parameters set the upper and lower set-point limits of the bath. DO NOT change the values of these parameters from the factory set values. To do so may present danger of the bath exceeding its temperature range causing damage or fire.

7.15 Operation Summary

A complete flowchart of controller operation is shown in Figure 9. This chart may be reproduced and used as a reference and operating guide.

8 Bath Calibration

In some instances the user may want to calibrate the bath to improve the temperature set-point accuracy. Calibration is done by adjusting the controller probe calibration constants R_0 and ALPHA so that the temperature of the bath as measured with a standard thermometer agrees more closely with the bath set-point. The thermometer used must be able to measure the bath fluid temperature with higher accuracy than the desired accuracy of the bath. By using a good thermometer and carefully following procedure the bath can be calibrated to an accuracy of better than 0.02°C over a range of 100°C.

8.1 Calibration Points

In calibrating the bath R_0 and ALPHA are adjusted to minimize the set-point error at each of two different bath temperatures. Any two reasonably separated bath temperatures may be used for the calibration however best results will be obtained when using bath temperatures which are just within the most useful operating range of the bath. The farther apart the calibration temperatures the larger will be the calibrated temperature range but the calibration error will also be greater over the range. If for instance 50°C and 150°C are chosen as the calibration temperatures then the bath may achieve an accuracy of say ±0.03°C over the range 40 to 160°C. Choosing 80°C and 120°C may allow the bath to have a better accuracy of maybe ±0.01°C over the range 75 to 125°C but outside that range the accuracy may be only ±0.05°C.

8.2 Measuring the Set-point Error

The first step in the calibration procedure is to measure the temperature errors (including sign) at the two calibration temperatures. First set the bath to the lower set-point which we will call t_L. Wait for the bath to reach the set-point and allow 15 minutes to stabilize at that temperature. Check the bath stability with the thermometer. When both the bath and the thermometer have stabilized measure the bath temperature with the thermometer and compute the temperature error err_L which is the actual bath temperature minus the set-point temperature. If for example the bath is set for a lower set-point of t_L=50°C and the bath reaches a measured temperature of 49.7°C then the error is –0.3°C.

Next, set the bath for the upper set-point t_H and after stabilizing measure the bath temperature and compute the error err_H. For our example we will suppose the bath was set for 150°C and the thermometer measured 150.1°C giving an error of +0.1°C.

8.3 Computing R_0 and ALPHA

Before computing the new values for R_0 and ALPHA the current values must be known. The values may be found by either accessing the probe calibration menu from the controller panel or by inquiring through the digital interface. The user should keep a record of these values in case they may need to be restored in the future. The new values R_0' and ALPHA′ are computed by entering the old values for R0 and ALPHA, the calibration temperature set-points t_L and t_H, and the temperature errors err_L and err_H into the following equations,

$$R_0' = \left[\frac{err_H\, t_L - err_L\, t_H}{t_H - t_L} ALPHA + 1\right] R_0$$

$$ALPHA' = \left[\frac{(1+ALPHA\, t_H)err_L - (1+ALPHA\, t_L)err_H}{t_H - t_L} + 1\right] ALPHA$$

If for example R_0 and ALPHA were previously set for 100.000 and 0.0038500 respectively and the data for t_L, t_H, err^L, and err_H were as given above then the new values R_0' and ALPHA′ would be computed as 100.193 and 0.0038272 respectively. Program the new values R_0 and ALPHA into the controller. Check the calibration by setting the temperature to t_L and t_H and measuring the errors again. If desired the calibration procedure may be repeated again to further improve the accuracy.

8.4 Calibration Example

The bath is to be used between 75 and 125°C and it is desired to calibrate the bath as accurately as possible for operation within this range. The current values for R_0 and ALPHA are 100.000 and 0.0038500 respectively. The calibration points are chosen to be 80.00 and 120.00°C. The measured bath temperatures are 79.843 and 119.914°C respectively. Refer to Figure 11 for applying equations to the example data and computing the new probe constants.

R0 = 100.000

ALPHA = 0.0038500

t_L = 80.00°C

measured t = 79.843°C

t_H = 120.00°C

measured t = 119.914°C

Compute errors,

err_L = 79.843 - 80.00°C = -0.157°C

err_H = 119.914 - 120.00°C = -0.086°C

Compute R_0,

$$R0' = \left[\frac{(-0.086) \times 80.0 - (-0.157) \times 120.0}{120.0 - 80.0} 0.00385 + 1 \right] 100.000 = 100.115$$

Compute ALPHA,

$$ALPHA' = \left[\frac{(1+0.00385 \times 120.0)(-0.157) - (1+0.00385 \times 80.0)(-0.086)}{120.0 - 80.0} + 1 \right] 0.00385 = 0.0038387$$

Figure 11. *Calibration Example.*

9 Repair and Maintenance

9.1 General Cleaning

The external parts of the bath should be cleaned regularly to remove oil. Spillage and drippings should be cleaned up immediately in order to prevent contamination of the work area. It is recommended that probes being tested are wiped clean with an absorbent material when they are withdrawn from the test well.

Stainless steel parts may be cleaned with an appropriate solvent cleaner such as MEK. Painted surfaces, however, SHOULD NOT be cleaned with a solvent. Instead a good oil removing soap or non-abrasive detergent may be used.

9.2 Fluid Tank

The fluid tank is accessed by removing the pump lid assembly. To do this, first disconnect the power pump cable and remove the probe. Next, unscrew the four screws located in the corners on top of the lid. Lift the lid by the edge, allowing any fluid that may be in the test well to drain back into the tank before setting the lid aside. The entire pump lid assembly will come out as a single unit. The assembly and the tank are then accessible for inspection, repair, cleaning or decontamination.

To reinstall the lid, follow the reverse procedure. Be sure the probe is replaced or temperature control will be impossible.

To drain the bath fluid first make sure the power is off. Place a container large enough to hold the entire volume of fluid beneath the drain. The drain for the hot and cold systems are behind their respective baths. The fluid is drained by unscrewing the cap (see Figure 6). The bath fluid will drain more quickly if it is warm enough to reduce its viscosity. However, it must be cool enough so as not to present a safety hazard.

Warning: Be sure that the fluids are at a safe temperature before draining tanks or removing the lid assembly.

When refilling the tank, be sure that the cap is screwed on tight and then follow instructions in section 3.3.

9.3 Mercury Spill

The bottom of the test well serves as a mercury trap. If a spill occurs, remove the pump lid assembly as described in the previous section. Carefully hold the pump lid assembly vertically so that the mercury will not run out through the pump. Mercury in the trap may be removed by inverting the test well over an appropriate disposal container. Inspect the fluid tank to see if any mercury has escaped the trap. Any mercury found there may be maneuvered into the drain hole located at the center of the tank bottom and then flushed out.

9.4 Heat Transfer Fluids

The heat transfer fluids recommended for the Model 7013 are Dow 710 for the hot system and Halocarbon 0.8 for the cold system. These fluids will cover the entire range of their respective baths. Other fluids may be used within their useful temperature ranges as long as they are compatible with the materials of construction. Water is the overall best fluid for temperature control over the range of 5 to 70°C. Flammable fluids may be used with extreme care, taking all appropriate safety precautions.

If the fluid should become contaminated or degraded beyond usability, replace it as previously described.

9.5 Temperature Controller

Should the temperature controller become inoperative, call the factory for instructions on returning it for repair.

9.6 Probe

The probe is a precision platinum sensor housed in a stainless steel sheath. The probe is sensitive to

shock so must always be handled carefully. A damaged probe may cause inaccuracy, poor stability, overheating or overcooling.

9.7 Refrigeration

The refrigeration of the Model 7013 consists of two compressors. The first compressor, or high stage, may be used to either cool the tank directly or to cool the low stage compressor in a cascade system where the low stage cools the tank.

The air-cooled condenser and the de-super heat coil at the front of the unit will both require occasional cleaning. When dust buildup becomes noticeable, remove the front grill by taking out the three thumbscrews located on its underside. Compressed air or a vacuum may then be used to clean the system. Dust buildup blocks air flow, causing high head pressures with reduced system capacity and lifetime. It is also important that the system have plenty of air space around it for sufficient air flow.

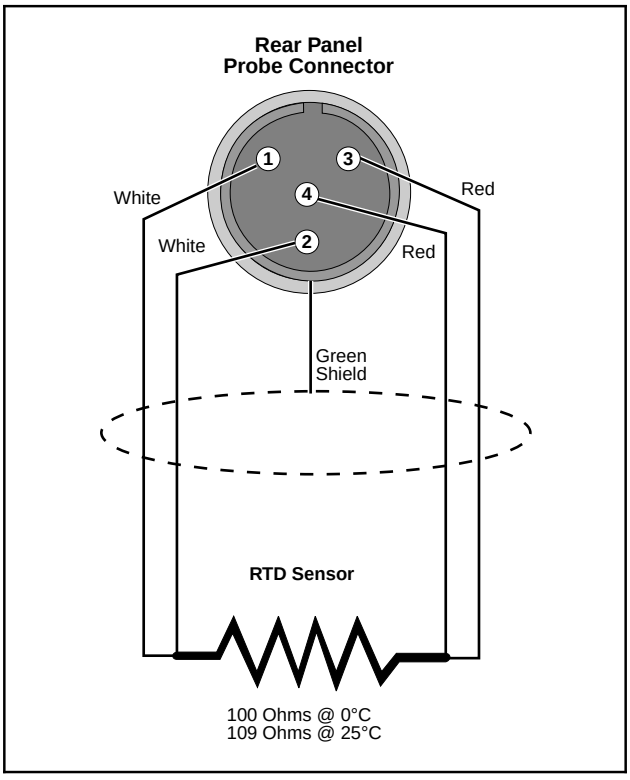

Figure 12. *Control Probe Connections.*

10 Appendix A – Refrigeration System and Component Description

The purpose of this section is to explain some of the more unique components and operations of the Hart 7013 refrigeration system. It does not attempt to describe the more generally known and understood components. Refer to the cold bath refrigeration diagram.

10.1 Ethylene System

10.1.1 DES-1 De-super Heater Coil

This coil is used to cool the ethylene refrigerant to room temperature prior to condensing it in the cascade condensing coil. This increases the efficiency of the system. Its fan also helps cool the ethylene compressor.

10.1.2 TS-1 Thermal Switch

When the Cascade condensing coil outlet is cooled by the R404a system to approximately –25°C, this switch closes and turns on the low stage, or ethylene system. This is to insure that cooling is sufficient before the ethylene compressor is turned on. Should the R404a compressor stop for some reason, this cutout will turn the ethylene compressor off before damage occurs.

10.1.3 ET-1 Expansion Tank

The expansion tank is used to allow an increased amount of refrigerant to be in the system while still having a low static pressure of 150 psi. This gives added cooling power without the problem of damaged components due to excessively high static pressures.

10.1.4 PG-2 Pressure Gauge

This gauge, located on the bottom front right of the Model 7013 bath, monitors the pressure that exists in the system after the capillary tubing and before the compressor. When the system is turned on the pressure will slowly come down until it nears the 0 psi mark. The pressure at this point is approximately equal to the compressor suction pressure. This gauge may also be used to check system charge. When the system components have reached pressure equilibrium at room temperature (approximately 25°C) it should read 140–150 psi.

10.1.5 EC-1 Evaporator Coil

The ethylene evaporator coil is located on the interior of the cold tank. This direct contact with the liquid to be cooled gives the greatest efficiency of heat transfer. Caution should be taken to insure that these coils are not bent or damaged when removing or replacing the lid.

10.2 R404a System

10.2.1 AEV-1 Automatic Expansion Valve

This valve controls the evaporative pressure of the R404a going to the coils on the side of the cold tank. It is set nominally at 0 psi for maximum efficiency over its cooling range. This valve is only in operation when cooling with the single stage mode.

10.2.2 TEV-1 Thermostatic Expansion Valve

This valve controls the cooling of the Cascade condensing coil.

10.2.3 CPR-1 Crankcase Pressure Regulator Valve

The CPR valve is used to limit the start-up suction pressure of the system. It is set at 10 to 12 psi, with a

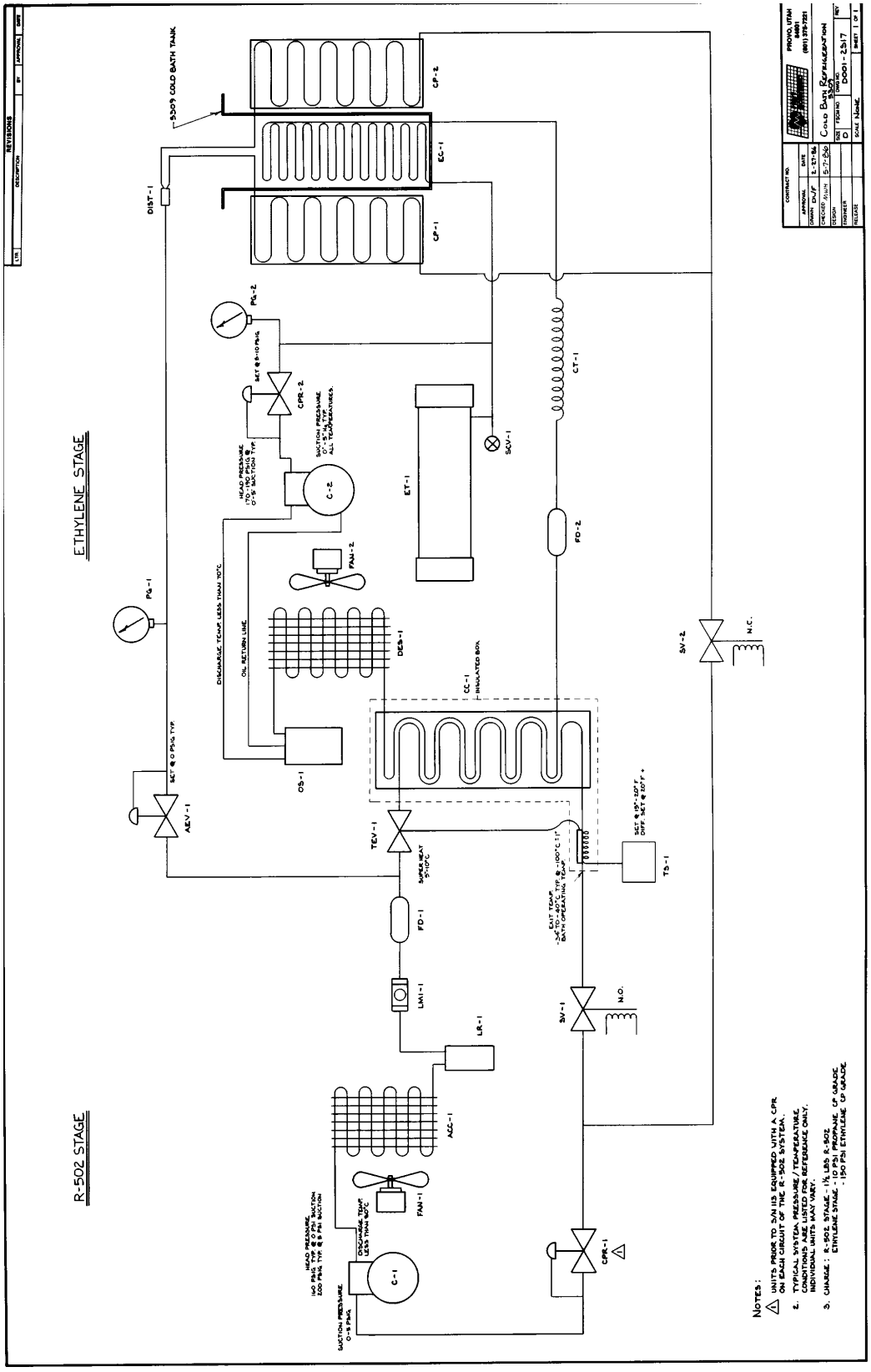

Figure 13 *Refrigeration Schematic.*

maximum current reading on the compressor of 5.8 amps.

10.2.4 SV-1 and SV-2 Solenoid Valves

SV-1 is normally open and is used to close off the cascade condenser. SV-2 is normally closed and is used to close off the cooling coils mounted on the sides of the cold tank. Both coils are powered in the single stage mode.

10.2.5 PG-1 Pressure Gauge

This gauge is used to monitor the evaporative pressure of the AEV valve used to cool the side-mounted coils of the single stage mode. As mentioned before, this pressure should read 0 psi. This gauge is not useful in two stage mode.

10.2.6 CC-1 Cascade Condenser

This is used as the second stage (ethylene) condenser of the two stage Cascade system.

10.2.7 CP-1 and CP-2 Cooling Plate Evaporators

The R404a evaporator coils are mounted to the outside of the cold tank. When the system is in single stage mode, R404a refrigerant is pumped through these coils. A liquid distributor (DIST-1) is used to insure that cooling to each side of the tank is equal.

10.2.8 Switching for R404a Stage

The R404a cooling circuit consists of two halves, the first going through the cascade condenser and the second through evaporator coils (CP-1 and CP-2) mounted to the sides of the tank. Switching between the two is accomplished by use of the solenoid valves (SV-1 and SV-2) mentioned above. These solenoids are powered by the refrigeration mode switch on the front panel.

11 Appendix B – Refrigeration Charging and Evacuation

Whenever either the R404a or the ethylene system is opened such that the entire charge is lost, the system must be evacuated before it can be recharged. If a thermistor vacuum gauge that registers in microns is available, evacuate the system to 30 to 50 microns (this usually takes 4 to 6 hours with a 4.5 CFM pump). This is a low enough vacuum to insure that all moisture is out of the system.

Warning: Moisture in the systems can cause component damage and inefficient operation of the unit.

Warning: DO NOT use a leak detector with ethylene gas in the system.

11.1 R404a System

This system should be charged with approximately 1.5 pounds of R404a refrigerant. After this is done, turn the system to the single stage mode. Let it run for a few minutes until equilibrium is reached and then check the sight glass to make sure that no gas bubbles are present. The pressure gauge (PG-1) should read 0 psi (adjust AEV-1 if required).

11.2 Ethylene System

Two types of refrigerants are used in this system, CP grade ethylene and CP grade propane. The propane is used to help reduce the viscosity of the refrigeration oil at low temperatures in the evaporator. First, evacuate the system to 50 microns. Next, add CP grade propane until pressure is 10 psi. Allow the system to settle for 10 or 15 minutes to insure that the system pressure has equalized. This process may have to be done a number of times before the static pressure remains constant at 10 psi. Next, add ethylene until the system charge reaches 150 psi. The system will tend to absorb some ethylene, making it necessary to add small amounts to top off the charge until the pressure becomes stable.

After the systems are charged, they are ready to run. Two things, however, need to be watched for. First, excessively high head pressures (over 250 psi for either system) that continue after five minutes of running can indicate system contaminants. Second, should the suction pressure of the ethylene system go below 6 or 7 inches of mercury, it is possible that moisture is present in the system and has frozen in the end of the capillary tube (CT-1). In either case, the charge must be dumped and the system re-evacuated.

12 Appendix C – Replacement Parts List

This appendix contains the replacement parts list for the Hart Scientific Model 7013 calibration bath. The sectional breakdown along with diagrams and descriptions in the other appendices of this manual will help identify The required components.

When ordering parts be sure to include the following information:

- Bath Model Number
- Bath Serial Number
- Part Number
- Part Description

The serial number information is found on the label on the back of the bath.

The parts list consists of REFERENCE DESIGNATOR, PART NUMBER, LEVEL, DESCRIPTION, QUANTITY, and UNITS (of measure):

1. The REFERENCE DESIGNATOR refers to alpha-numeric designators used in figures and/or drawings elsewhere in this manual where applicable.
2. The PART NUMBER is the Hart Scientific number.
3. The LEVEL, where shown, indicates levels of assembly, e.g., an assembly listed at LEVEL 1 may have sub-assemblies or components listed at LEVEL 2. Items at LEVEL 2 may have components listed at level 3, and so on.
4. The DESCRIPTION, QUANTITY, and UNITS are also given for identification and ordering purposes.

7013 TOP ASSEMBLY

REFERENCE DESIGNATOR	PART NUMBER	LEVEL	DESCRIPTION	QTY	UNITS
	00110490	1	LID ASSEMBLY - COMPLETE	1	EACH
	00110500	2	PUMP ASSEMBLY	1	EACH
	85801000	3	STIRRING PROPELLER	1	EACH
	70102106		LID MOUNTING SCREWS (10-32 X 2 3/8 PAN HEAD)	4	EACH
	00110510		AMBIENT GUARD ASSEMBLY	2	EACH
	87192624		CONTROL PROBE, 14 inch, 100Ω	2	EACH
	75350710		OIL, HOT BATH DOW 710	2	GAL
	75350080		OIL, COLD BATH HALOCARBON 0.8	2	GAL

7013 CHASSIS

REFERENCE DESIGNATOR	PART NUMBER	LEVEL	DESCRIPTION	QTY	UNITS
	73101632		CASTER, 16-32-XD	4	EACH

7013 COLD BATH

REFERENCE DESIGNATOR	PART NUMBER	LEVEL	DESCRIPTION	QTY	UNITS
	00160090		COLD BATH INSULATION KIT	1	EACH
	00153520		COLD BATH TANK & FLANGE, WELDMENT	1	EACH
	00150080		COLD BATH HEATER KIT	2	EACH
	00153550		COOLING PLATE ASSEMBLY	2	EACH
	00153540		THERMOCOUPLE ASSEMBLY	1	EACH
	00153450		COOLING COIL	1	EACH
	70610381		LID STANDOFF, #10-32ML TO FM 3/8HEX	4	EACH
	00160040		LID GASKET KIT	1	EACH
	28021000		FUSE, 10A 125V	2	EACH
	21022010		FUSE, 20A 250V SB	2	EACH

7013 HOT BATH

REFERENCE DESIGNATOR	PART NUMBER	LEVEL	DESCRIPTION	QTY	UNITS
	00160050		HOT BATH INSULATION KIT	1	EACH
	00153530		HOT BATH TANK & FLANGE, WELDMENT	1	EACH
	00153540		THERMOCOUPLE ASSEMBLY	1	EACH
	00160060		HOT BATH CONTROL HEATER KIT	2	EACH
	00160070		BOOST HEATER KIT	2	EACH
	00160040		LID GASKET KIT	1	EACH
	00110420		BLOWER EXHAUST ASSEMBLY	1	EACH
	00110430		EXHAUST VALVE HANDLE ASSEMBLY	1	EACH
	28021000		FUSE, 10A 125V	2	EACH
	28021510		FUSE, 15A 250V SB	2	EACH

7013 POWER CONTROL PANEL

REFERENCE DESIGNATOR	PART NUMBER	LEVEL	DESCRIPTION	QTY	UNITS
	25231703		BOOSTER HEATER & BLOWER SWITCH	2	EACH
	30004000		BLOWER & REFRIG. BLUE LIGHT	3	EACH
	30002010		BOOSTER HEATER RED NEON LIGHT	1	EACH
	53525339		VOLTAGE REDUCTION RESISTOR,,39K 1/4W	3	EACH
	25231703		HEATER POWER SWITCH	2	EACH
	25105100		HOT BATH POWER SWITCH	1	EACH
	25231703		REFRIGERATION MODE SWITCH	1	EACH
	25105100		COLD BATH POWER SWITCH	1	EACH

	25231055		CUTOUT RELAY	2	EACH

7013 COOLING BLOWER ASSEMBLY

REFERENCE DESGNATOR	PART NUMBER	LEVEL	DESCRIPTION	QTY	UNITS
	00110400	1	COOLING BLOWER ASSEMBLY, COMPLETE	1	EACH
	85101880	2	D-188 230V 1500 RPM MOTOR	1	EACH
	85105110	2	BLOWER FAN, AL SQRL CAGE	1	EACH

7013 REFRIGERATION

REFERENCE DESIGNATOR	PART NUMBER	LEVEL	DESCRIPTION	QTY	UNITS
C-2	00116011		1 /2" SERViCE VALVE KIT	2	EACH
	00116012		3/8" SERVICE VALVE KIT	2	EACH
CPR-2	82106000		CRO-6-0/60-5/8 ODF CPR	1	EACH
OS-1	82405581		S-5581 AC&R OIL SEPARATOR	1	EACH
FAN-2	85105421		5421 9W 230V CW FAN MOTOR	1	EACH
	85105012		GEMLINE FB1O6 FAN BLADE	1	EACH
DES-1	83000100		50639 DE-SUPER HEAT COIL	1	EACH
TS-1	87521000		016-104 RAMCO THERMAL SWITCH	1	EACH
FD-2	82300114		D-114 GEMLINE FILTER/DRYER	1	EACH
PG-2	82200500		HIGH PRESS GAUGE MARSH J4320	1	EACH
	75351150		OIL, ZEROL 150 SUS REF.	1	EACH
CT-1	82910001		BC-1 CAPILLARY TUBE (100" LONG)	1	EACH
	75311000		ETHYLENE GAS		As Required
	75312000		PROPANE GAS		As Required
C-1	83006200		COMPRESSOR, KAJ3-0075-CAV	1	EACH
	83006220		STARTING RELAY ASSEMBLY	2	EACH
ACC-1	83000200		-1075-00 COND. COIL	1	EACH
LR-1	83000300		51067-1 LIQUID RECEIVER	1	EACH
FAN-1	85105821		5821 16W 230V CW 155ORPM	1	EACH
	85105014		FB 109 FAN BLADE	1	EACH
AEV-1	82100740		104-740 SINGER EXP VALVE	1	EACH
	00150460		B001-5046 VALVE CLAMP	1	EACH
TEV-1	82101502		SPORLAN #502 TX VALVE	1	EACH
CPR-1	82106000		CRO-6-0/60-5/8 ODF CPR	2	EACH
CC-1	83004150		CASCADE CONDENSER COAX 150H	1	EACH
LMI-1	82300118		SG118R SIGHT GLASS	1	EACH
FD-1	82300114		D-114 GEMLINE FILTER/DRYER	1	EACH

PG-1	82200250		M2-250 LOW PRESS GAUGE MARSH J4320	1	EACH
SV-1, SV-2	82112000		0E9S240 SPORLAN SOL. VALVE	2	EACH
	82112010		OMKC-2 230VAC SOLENOID COIL	2	EACH
	75310502		R502 REFRIGERANT		As Required
CD-1, CD-2	00153550		COOLING PLATE EVAPORATOR	2	EACH
EC-1	30015345		EVAPORATOR COIL	1	EACH

7013 REAR POWER PANEL

REFERENCE DESIGNATOR	PART NUMBER	LEVEL	DESCRIPTION	QTY	UNITS
	23760103		8043.2.40.60 SOCKET, PUMP POWER	2	EACH
	23712004		PROBE SOCKET TB4M, SWITCHCRAFT	2	EACH
	81106000		B-600-71-4 DRAIN BULKHEAD CONN.	2	EACH
	81107216		E1-6B DRAIN ELBOW 3/8FLR 1/4MPT	2	EACH
	81107236		DRAIN CAP NFTS-6 3/8" CAP	2	EACH

13 Appendix D - Digital Interface

If supplied with the option, the 7013 bath is capable of communicating with and being controlled by other equipment through the digital interface. Two types of digital interface are available — the RS-232 serial interface and the IEEE-488 GPIB interface.

With a digital interface the bath may be connected to a computer or other equipment. This allows the user to set the bath temperature, monitor the temperature, and access any of the other controller functions, all using remote communications equipment. In addition the heater power setting and cooling capacity may be controlled using the interface. The two baths of the 7013 are connected, set up, and controlled independently. With a few noted exceptions the following instructions apply to either bath. To allow the functions to be switched using the interface the “HEATER POWER” and “BOOST HEATER” switches must be set to the “OFF” position. The “REFRIGERATION MODE” and the “COOLING BLOWER” switches must also be set to “OFF”.

Digital Interface Setup:

HEATER switches - LOW

BOOST switch - OFF

BLOWER switch - OFF

REFRIGERATION switch - OFF

13.1 Serial communications

The bath may be installed with an RS-232 serial interface that allows serial digital communications over fairly long distances. With the serial interface the user may access any of the functions, parameters and settings discussed in Section 7 with the exception of the BAUD rate setting.

13.1.1 Wiring

The serial communications cable attaches to the bath through the D-9 connector on the front panel. Figure 14 shows the pin-out of this connector and suggested cable wiring.

13.1.2 Setup

Before operation the serial interface of the bath must first be set up by programming the BAUD rate and other configuration parameters. These parameters are programmed within the serial interface menu. The serial interface parameters menu is outlined in Figure 9 on page 30.

To enter the serial parameter programming mode first press “EXIT” while pressing “SET” and release to enter the secondary menu. Press “SET” repeatedly until the display reads "ProbE". This is the menu selection. Press “UP” repeatedly until the serial interface menu is indicated with "SErIAL". Finally press “SET” to enter the serial parameter menu. In the serial interface parameters menu are the BAUD rate, the

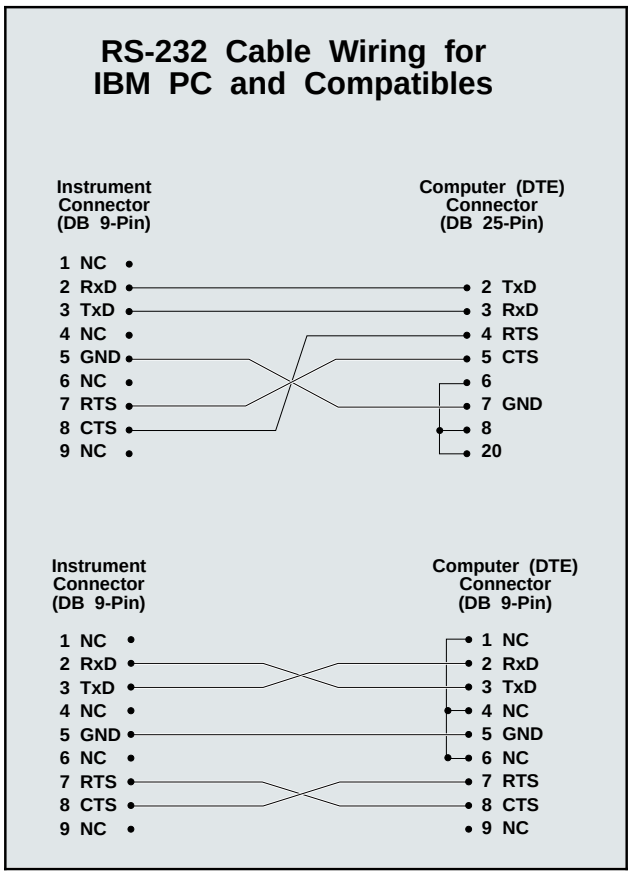

Figure 14. *Serial Cable Wiring.*

sample rate, the duplex mode, and the linefeed parameter.

13.1.2.1 BAUD rate

The BAUD rate is the first parameter in the menu. The display will prompt with the BAUD rate parameter by showing “BAUd”. Press “SET” to choose to set the BAUD rate. The current BAUD rate value will then be displayed. The BAUD rate of the serial communications may be programmed to 300, 600, 1200, or 2400 BAUD. The BAUD rate is pre-programmed to 1200 BAUD. Use “UP” or “DOWN” to change the BAUD rate value. Press “SET” to set the BAUD rate to the new value or “EXIT” to abort the operation and skip to the next parameter in the menu.

13.1.2.2 Sample period

The sample period is the next parameter in the menu and prompted with “SAmPLE”. The sample period is the time period in seconds between temperature measurements transmitted from the serial interface. If the sample rate is set to 5 for instance then the bath will transmit the current measurement over the serial interface approximately every five seconds. The automatic sampling is disabled with a sample period of 0. Press “SET” to choose to set the sample period. Adjust the period with “UP” or “DOWN” and then use “SET’ to set the sample rate to the displayed value.

13.1.2.3 Duplex mode

The next parameter is the duplex mode indicated with “dUPL”. The duplex mode may be set to half duplex (“HALF”) or full duplex (“FULL”). With full duplex any commands received by the bath via the serial interface will be immediately echoed or transmitted back to the controlling device. With half duplex the commands will be executed but not echoed. The default setting is full duplex. The mode may be changed using “UP” or “DOWN” and pressing “SET”.

13.1.2.4 Linefeed

The final parameter in the serial interface menu is the linefeed mode. This parameter enables (“On”) or disables (“OFF”) transmission of a linefeed character (LF, ASCII 10) after transmission of any carriage-return. The default setting is with linefeed on. The mode may be changed using “UP” or “DOWN” and pressing “SET”.

13.1.3 Serial operation

Once the cable has been attached and the interface set up properly the controller will immediately begin transmitting temperature readings at the programmed rate. The set-point and other commands may be sent to the bath via the serial interface to set the bath and view or program the various parameters. The interface commands are discussed in Section 13.3 and listed in Table 1.

13.2 IEEE-488 Communication

The IEEE-488 interface is available as an option. Baths supplied with this option may be connected to a GPIB type communication bus which allows many instruments to be connected and controlled simultaneously.

13.2.1 Setup

To use the IEEE-488 interface first connect an IEEE-488 standard cable to the port on the bath fornt panel. Next set the device address. This parameter is programmed within the IEEE-488 interface menu. The IEEE-488 interface parameters menu is outlined in Figure 9 on page 30.

To enter the IEEE-488 parameter programming menu first press “EXIT” while pressing “SET” and release to enter the secondary menu. Press “SET” repeatedly until the display reaches “PrObE”. This is the menu selection. Press “UP” repeatedly until the IEEE-488 interface menu is indicated with “IEEE”. Press “SET” to enter the IEEE-488 parameter menu. The IEEE-488 menu contains the IEEE-488 address parameter.

13.2.1.1 IEEE-488 interface address

The IEEE-488 address is prompted with “AddrESS”. Press “SET” to program the address. The default address is 22. Change the device address of the bath if necessary to match the address used by the communication equipment by pressing “UP” or “DOWN” and then “SET”.

13.2.1.2 End-of-string

The-end-string (EOS) character can be set to carriage-return (CR), linefeed (LF), or both. Any data string transmitted from the bath with be terminated

Table 1 *Interface Command Summary.*

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Display Temperature					
Read current set-point	s[etpoint]	s	set: 9999.99 {C or F}	set: 150.00 C	
Set current set-point to n	s[etpoint]=n	s=450			Instrument Range
Read vernier	v[ernier]	v	v: 9.99999	v: 0.00000	
Set vernier to n	v[ernier]=n	v=.00001			Depends on Configuration
Read temperature	t[emperature]	t	t: 9999.99 {C or F}	t: 55.69 C	
Read temperature units	u[nits]	u	u: x	u: c	
Set temperature units:	**u[nits]=c/f**				C or F
Set temperature units to Celsius	u[nits]=c	u=c			
Set temperature units to Fahrenheit	u[nits]=f	u=f			
Secondary Menu					
Read proportional band setting	pr[op-band]	pr	pr: 999.9	pr: 15.9	
Set proportional band to *n*	pr[op-band]=n	pr=8.83			Depends on Configuration
Read cutout setting	c[utout]	c	c: 9999 {x},{xxx}	c: 620 C, in	
Set cutout setting:	**c[utout]=n/r[eset]**				
Set cutout to *n* degrees	c[utout]=n	c=500			Temperature Range
Reset cutout now	c[utout]=r[eset]	c=r			
Read heater power (duty cycle)	po[wer]	po	po: 9999	po: 1	
Configuration Menu					
Probe Menu					
Read R0 calibration parameter	r[0]	r	r0: 999.999	r0: 100.578	
Set R0 calibration parameter to *n*	r[0]=n	r=100.324			98.0 to 104.9
Read ALPHA calibration parameter	al[pha]	al	al: 9.9999999	al: 0.0038573	
Set ALPHA calibration parameter to *n*	al[pha]=n	al=0.0038433			.00370 to .00399
Operating Parameters Menu					
Read cutout mode	cm[ode]	cm	cm: xxxx	cm: AUTO	
Set cutout mode:	**cm[ode]=r[eset]/a[uto]**				RESET or AUTO
Set cutout to be reset manually-	cm[ode]=r[eset]	cm=r			
Set cutout to be reset automatically	cm[ode]=a[uto]	cm=a			
Serial Interface Menu					
Read serial sample setting	sa[mple]	sa	sa: 9	sa: 1	
Set serial sampling setting to *n* seconds	sa[mple]=n	sa=0			0 to 4000
Set serial duplex mode:	**du[plex]=f[ull]/h[alf]**				FULL or HALF
Set serial duplex mode to full	du[plex]=f[ull]	du=f			
Set serial duplex mode to half	du[plex]=h[alf]	du=h			
Set serial linefeed mode:	**lf[eed]=on/of[f]**				ON or OFF
Set serial linefeed mode to on	lf[eed]=on	lf=on			
Set serial linefeed mode to off	lf[eed]=of[f]	lf=of			

Interface Command Summary continued.

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Calibration Menu					
Read C0 calibration parameter	*c0	*c0	c0: 9	c0: 0	
Set C0 calibration parameter to *n*	*c0=n	*c0=0			–999.9 to 999.9
Read CG calibration parameter	*cg	*cg	cg: 999.99	cg: 406.25	
Set CG calibration parameter to *n*	*cg=n	*cg=406.25			–999.9 to 999.9
Read B0 calibration parameter	*b0	*b0	b0: 9	b0: 0	
Set B0 calibration parameter to *n*	*b0=n	*b0=0			–999.9 to 999.9
Read BG calibration parameter	*bg	*bg	bg: 999.99	bg: 156.25	
Set BG calibration parameter to *n*	*bg=n	*bg=156.25			–999.9 to 999.9
Read low set-point limit value	*tl[ow]	*tl	tl: 999	tl: –80	
Set low set-point limit to *n*	*tl[ow]=n	*tl=-80			–999.9 to 999.9
Read high set-point limit value	*th[igh]	*th	th: 999	th: 205	
Set high set-point limit to *n*	*th[igh]=n	*th=205			–999.9 to 999.9
Miscellaneous (not on menus)					
Read firmware version number	*ver[sion]	*ver	ver.9999,9.99	ver.2100,3.56	
Read structure of all commands	h[elp]	h	list of commands		
Hot Bath Controls					
Read Medium Heaters	f1	f1	f1:9	f1:1	
Set Medium Heaters	**f1=1/0**				**1 or 0**
Set medium heater to on	f1=*n*	f1=1			
Set medium heater to off	f1=*n*	f1=0			
Read Blower Fan	f2	f2	f2:9	f2:0	
Set Blower Fan	**f2=1/0**				**1 or 0**
Set Blower Fan to on	f2=*n*	f2=1			
Set Blower Fan to off	f2=*n*	f2=0			
Read High Heaters	f3	f3	f3:9	f3:1	
Set High Heaters	**f3=1/0**				**1 or 0**
Set High Heater to on	f3=*n*	f3=1			
Set High Heater to off	f3=*n*	f3=0			
Read Boost Heaters	f4	f4	f4:9	f4:1	
Set Boost Heaters	**f4=1/0**				**1 or 0**
Set Boost Heater to on	f4=*n*	f4=1			
Set Boost Heater to off	f4=*n*	f4=0			
Cold Bath Controls					
Read Medium Heaters	f1	f1	f1:9	f1:1	
Set Medium Heaters	**f1=1/0**				**1 or 0**
Set Medium Heater to on	f1=*n*	f1=1			
Set Medium Heater to off	f1=*n*	f1=0			
Read Stage 1 Cooling	f2	f2	f2:9	f2:0	
Set Stage 1 Cooling	**f2=1/0**				**1 or 0**
Set Stage 1 Cooling to on	f2=*n*	f2=1			
Set Stage 1 Cooling to off	f2=*n*	f2=0			
Read High Heaters	f3	f3	f3:9	f3:1	
Set High Heaters	**f3=1/0**				**1 or 0**
Set High Heater to on	f3=*n*	f3=1			
Set High Heater to off	f3=*n*	f3=0			

Interface Command Summary continued.

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Read Stage 2 Cooling	f4	f4	f4:9	f4:1	
Set Stage 2 Cooling	f4=1/0				**1 or 0**
Set Stage 2 Cooling to on	f4=*n*	f4=1			
Set Stage 2 Cooling to off	f4=*n*	f4=0			

Legend:	[] Optional Command data
	{} Returns either information
	n Numeric data supplied by user
	9 Numeric data returned to user
	x Character data returned to user
Note:	When DUPLEX is set to FULL and a command is sent to READ, the command is returned followed by a carriage return and linefeed. Then the value is returned as indicated in the RETURNED column.

according to this setting. The bath will interpret either a CR or LF character recieved as EOS.

13.2.2 IEEE-488 operation

Commands may now be sent via the IEEE-488 interface to read or set the temperature or access other controller functions. All commands are ASCII character strings and are terminated with a carriage-return (CR, ASCII 13) or linefeed (LF, ASCII 10). Interface commands are listed below.

13.3 Interface Commands

The various commands for accessing the bath controller functions via the digital interfaces are listed in this section (see Table 1 on page 52). These commands are used with either the RS-232 serial interface or the IEEE-488 GPIB interface. The commands must be terminated with a carriage-return or linefeed character. The interface makes no distinction between upper and lower case letters, hence either may be used. Commands may be abbreviated to the minimum number of letters which uniquely determines a command. A command may be used to either set a parameter or display a parameter depending on whether or not a value is sent with the command following an “=” character. For example “s”<CR> will return the current set-point and “s=50.00”<CR> will set the set-point to 50.00 degrees.

In the list of commands in Table 1, characters or data within brackets, “[” and “]”, are optional for the command. A slash, “/”, denotes alternate characters or data. Numeric data, denoted by “n”, may be entered in decimal or exponential notation. Bold type characters are literal characters while normal type symbolizes data. Characters are shown in lower case although upper case may be used. Spaces may be added within command strings and will simply be ignored. Backspace (BS, ASCII 8) may be used to erase the previous character.

13.4 Power Control Functions

The digital interface is capable of controlling the heating and cooling functions so that the bath can be remotely operated at any temperature within the range of the bath. *To allow the interface to control the heating and the cooling, the front panel controls must be disabled by switching all controls (except the main power switches) to “OFF”.*

The hot and cold baths each have four control functions with the digital interface. For the hot bath these are 1) Medium Heater, 2) Blower Fan, 3) High Heater, and 4) Boost Heater. For the cold bath these are 1) Medium Heater, 2) Stage 1 Cooling, 3) High Heater, and 4) Stage 2 Cooling. These functions are summarized in Tables 2 and 3 and sample commands are shown in Table 1 starting on page 52.

Table 2 *Hot Bath Control Functions.*

Function Seetting	F1	F2	F3	F4
Low Heat	0	x	0	x
Medium Heat	1	x	0	x
High Heat	x	x	1	x
Blower	x	1	x	x
Boost Heat	x	x	x	1

Note: “x” indicates that the command is disabled in this function.

Table 3 *Cold Bath Control Functions.*

Function Setting	F1	F2	F3	F4
Low Heat	0	x	0	x
Medium Heat	1	x	0	x
High Heat	x	x	1	x
Stage 1 Cooling	x	1	x	x
Stage 2 Cooling	x	x	x	1

Note: “x” indicates that the command is disabled in this function.

13.4.1 Hot Bath Control

To control the heaters with the digital interface the front panel heater switch must be set to “LOW” and the Boost Heater and Blower Fan need to be set in the “OFF” position. The heater function is controlled with the “F1" and “F3” commands. “F2” controls the Blower Fan and “F4” controls the Boost Heater. These commands are either set to 0 or 1 according to Table 2. The default settings are F1=0 and F3=0 which is “LOW”. For example the commands “F1=1" and “F3=0” will set the heater power to “MEDIUM”. The boost heater is similarly controlled by command “F4" to set it on (1) or off (0). Giving the commands with no parameter (0 or 1) will query the bath for the current function setting.

13.4.2 Cold Bath Control

To control the refrigeration power of the cold bath with the digital interface the front panel Refrigeration Mode switch must be “OFF” and the Heater Switch must be set to “LOW”. The Stage 1 Cooling is controlled on or off with the “F2" command, 1 for “ON” and 0 for “OFF”. The stage 2 is controlled with the ”F4" command, 0 for “LOW” and 1 for “HIGH” as shown in Table 3 along with the heater functions.

14 Appendix E—Wiring Diagram

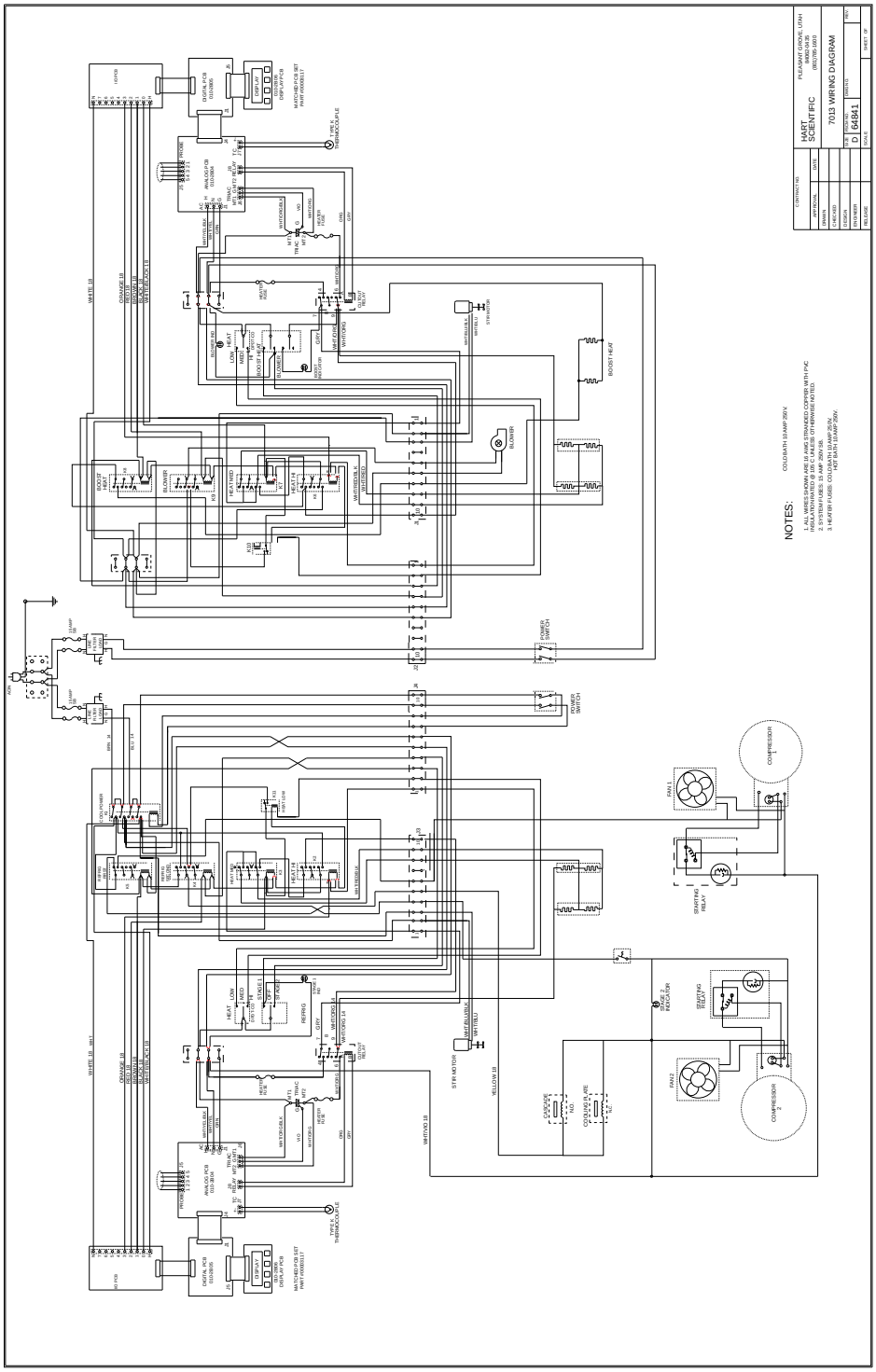

Figure 15 *7013 Wiring Diagram.*